The Institute of Physics

BULLETIN

APRIL 1957 VOL. 8 · No. 4

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The Bulletin is published by The Institute of Physics for circulation to its members.

Notices to Members

Thirty-seventh Annual General Meeting

Notice is hereby given that the Thirty-seventh Annual General Meeting of The Institute of Physics will be held at 4.45 p.m. on Friday, July 12, 1957, in the Clarendon Laboratory, Oxford. Attendance is limited to Fellows and Associates of the Institute. The business to be conducted is the consideration of the Board's report, the accounts and balance sheets for 1956, the declaration of the election of the Honorary Officers and other members of the Board nominated, and the election of auditors. A copy of the annual report and accounts is printed in this issue of the *Bulletin*. Further copies will be sent on request.

F. A. VICK,
April 10, 1957 *Honorary Secretary.*

Nominations to the Board

In accordance with Article 47 of the Articles of Association of the Institute, notice is hereby given that the Board has nominated the undermentioned persons to fill the vacancies stated which will occur on September 30, 1957.

The Ordinary Members nominated were selected by ballot from a list of suggestions made by Branch and Group Committees and members of the Board.

Attention is directed to the terms of Article 48 which reads as follows : " After the notice (*i.e. this notice*) mentioned in the last preceding Article any five Members (*i.e. Fellows and Associates*) may nominate within two weeks of receipt by them respectively of such notice, but not later, any other duly qualified person as a candidate for election to any one or more of the said Offices by depositing such nomination in writing at the Registered Office of the Institute together with the written consent of the nominee to accept office if elected. No member may nominate more than one candidate in any year." Ballot papers will be circulated in due course to Fellows and Associates and the result of the ballot will be announced at the Annual General Meeting on July 12 next.

President :

*O. W. HUMPHREYS, C.B.E., B.Sc., M.I.E.E., F.Inst.P., Director in Charge of Research, The General Electric Co. Ltd., Wembley, Middlesex.

Vice-President (one vacancy) :

PROFESSOR E. C. STONER, B.A., Sc.D., F.Inst.P., F.R.S., Professor of Physics, The University of Leeds.

Hon. Treasurer:

*J. TAYLOR, M.B.E., Ph.D., D.Sc., F.R.I.C., M.I.Min.E., F.Inst.P., Director, Imperial Chemical Industries Ltd.

Hon. Secretary:

*PROFESSOR F. A. VICK, O.B.E., B.Sc., Ph.D., A.M.I.E.E., F.Inst.P., Professor of Physics, University College of North Staffordshire.

Ordinary Members (two vacancies) :

F. OLDHAM, M.A., B.Sc., F.Inst.P., Headmaster, Hinckley Grammar School, Leics.

J. THEWLIS, D.Sc., F.Inst.P., Senior Principal Scientific Officer, Atomic Energy Research Establishment, Harwell, Berks.

F. A. VICK,
April 10, 1957 *Honorary Secretary.*

* *For re-election to the same office*

The retiring members of the Board whose period of service expires on September 30 are Mr. G. R. Noakes (*Vice-President*) and Dr. P. S. Henry and Mr. A. T. Pickles (*Ordinary Members*). The other members of the Board, whose names are given on the inside front cover of the *Bulletin*, have not completed their periods of service and will continue to serve.

Oxford Convention

Members are reminded that the forms of application for attendance at the Oxford Convention should be returned as soon as possible, and no later than **April 30.** Additional forms will be sent on request.

New publications available at reduced rates

The Physics of Non-Destructive Testing with particular reference to some new aspects.

This is Supplement No. 6 to the *British Journal of Applied Physics.* [Bound in stiff boards ; pp. 70 with index and 76 figures ; retail price 25s. net (special price to members of the Institute of all grades for their *personal* use—15s. including postage).]

Orders with remittance should be sent on the form enclosed with this *Bulletin* ; publication will be about the end of May and copies will be dispatched on publication. Members are reminded that copies of the Supplements are no longer supplied without extra charge to those subscribing to the *British Journal of Applied Physics.*

The contributions published in this Supplement are selected from those presented during the past few months at meetings of the Non-Destructive Testing Group of the Institute. They include most of those read at the conference held in Bristol in July, 1956.

In his foreword, Dr. J. Thewlis of the Atomic Energy Research Establishment, Harwell, the Chairman of the Non-Destructive Testing Group, writes : " The purpose of presenting this collection is to enable engineers, metallurgists and indeed all those concerned with non-destructive testing, to appreciate the importance of the new methods which are resulting from applications of physics to this field and to give them an opportunity of considering how far further suggestions for utilizing the physical behaviour of substances under various conditions can be used and developed as methods for non-destructive testing."

Laboratory and Workshop Notes. 1953-1955

Dr. Ruth Lang has compiled a fourth volume of laboratory and workshop notes from the *Journal of Scientific Instruments,* and this is to be published by Edward Arnold (Publishers) Ltd. at the end of May. Members of the Institute are entitled to purchase copies at a reduced price of 23s. 6d.

(retail price 30s.) prior to publication and a form for this purpose is enclosed with this *Bulletin.* Members in the United Kingdom wishing to take advantage of the reduced rate must return this by May 22, and those living abroad are asked to return it as soon as possible. The royalties from this book will be donated to the Institute's Benevolent Fund as have those of the three earlier similar volumes, all of which have sold very well.

A Further Handbook of Industrial Radiology

Mr. W. J. Wiltshire has edited a volume entitled *A Further Handbook of Radiology* contributed by members of the Non-Destructive Testing Group of the Institute. This will be published by Edward Arnold (Publishers) Ltd. at the end of May. The fifteen contributions are concerned with new developments which are now available to workers using radiological inspection. Members of the Institute are entitled to purchase copies at a reduced price of 39s. (retail price 50s.) prior to publication and a form for this purpose is enclosed with this *Bulletin.* Members in the United Kingdom wishing to take advantage of the reduced rate must return this by May 22, and those living abroad are asked to return it as soon as possible. The royalties from this book will be donated to the Institute's Benevolent Fund, as were those of the original *Handbook of Industrial Radiology*, published in 1944.

Australian Branch Exhibition

An Exhibition of Scientific Instruments and Apparatus arranged by the Victorian Division of the Institute was held in the Physics Department of the University of Melbourne on March 5–7. Such exhibitions have now become a regular feature of Institute of Physics activities in Australia, being arranged at intervals of eighteen months alternately in Melbourne and Sydney. This latest exhibition, the fifth in the series, was opened on Tuesday, March 5, by the Hon. Howard Beale, Q.C., Minister for Supply and Minister for Defence Production in the Australian Government, who stressed the need for training more scientists and technologists.

Forty private firms and eight government departments exhibited equipment. One noticeable feature was the considerable local content in the exhibition ; since the war an increasing number of Australian firms have become interested in the manufacture of high quality scientific equipment. The estimated total attendance for the three afternoon and three evening sessions was three thousand.

The Institute's Finances

For those members who wish to have a simple general picture of the Institute's financial affairs as a whole, a set of consolidated accounts is published in the *Bulletin* each year. These combine the accounts which will be found in the more formal statements included in the Board's annual report (p. 139 of this issue) to be presented for adoption to the Annual General Meeting to be held on July 12 next.

Thanks largely to the budgetary control that is now exercised, the year 1956 ended with a small surplus (£1,330), in spite of rising costs and the increase of £800 p.a. in the rent of the House. In comparing this with the November, 1955, budget figure of £815, it must be noted that the original estimate did not provide for the repayment of the £500 borrowed from the X-ray Index Fund towards the cost of production of a book, nor for the stock depreciation of £1,350, which represents books and journals sold and not replaced by new stock. It is gratifying to note that members' fees were nearly £1,000 more than in 1955 and £833 more than the figure in the estimates for the year.

Members will recall that in October, 1955, the Board in asking for authority to make an additional charge to those who wished to receive the Journals stated that " to safeguard the Institute during the next few years, it is necessary to increase its income by at least £4,000 p.a. above the present level, apart from increased subscription income arising from new members." This has been achieved, and it has been possible to postpone further increases in members' subscription rates which at that time was considered likely to be necessary by January, 1957.

Turning now to the consolidated balance sheet (p. 114) it will be seen, however, that the Institute's reserves remain far too slender and their rate of growth too slow to allow for any complacency. Therefore the Board finds it necessary, once more, to state that it cannot enter into new commitments for the present, as such small surpluses as there are on the year's working must be used to replenish the reserves which were heavily drawn upon in the years immediately following the war.

The money entered as " Bank Balances and Cash in Hand " is for the most part in deposit accounts and, as will be seen from the other side of this balance sheet, nearly £10,000 is in respect of the 1957 volumes of the Journals, and will be required later in the year to meet the printing bills.

Finally, reference must be made to the X-ray Index Fund which has now reached nearly £17,000. This is derived from the sales of the copies of the card index file of X-ray diffraction data, presented to the Institute by the American Society for Testing Materials, in recognition of the British contribution to this work and to be used for its continuation. Negotiations are proceeding to establish this as a separate Trust Fund within the Institute.

Correspondence

In his interesting analysis of the sources and potential sources of technologists Dr. Venables* mentions the possibility of training more girls. If girls are to make a substantial contribution, the problem will have to be approached from both ends.

Firstly, girls' schools will have to offer an elementary scientific education as thorough and as long as that offered by boys' schools. Too often the science course leads to the G.C.E. Ordinary level subject of " General Science " which is not an adequate basis for Advanced level science subjects. No boys or girls have their studies of, for example, French, Latin and German condensed into " General languages " to allow them more time to study science. Those girls' schools which would like to expand their science teaching are handicapped by shortage of staff, shortage of laboratories and even shortage of girls willing to study science to Advanced level.

My second point has been much less publicized. Dr. Venables quotes a ratio of one girl to seven boys at G.C.E. Advanced level; Table 3 of the Salary Survey† shows a ratio of one woman to forty-nine men in the Institute's membership of all grades, and the ratio in the Engineering Institutions is much larger. This implies that a large proportion of the girls who do take G.C.E. in science do not become professional scientists for any length of time. This fact is no doubt obvious without the support of figures, but it shows that any effort put into increasing and improving the teaching of science in girls' schools will be largely wasted unless more use can be made of the services of those women who are already trained.

The majority of women, scientists being no exception, marry and have families. If full use is to be made of their training, industry and other employers of scientists will have to offer part-time work. A conscientious woman feels that her first duty is to her family and, however much she would like to work professionally, she will not do so if she considers her family would suffer.

Perhaps those who draft paragraphs in the " Sits. Vac." and " Scientists Wanted " columns of our papers might consider adding this to their list of inducements. The teaching profession is already using the part-time services of married women scientists satisfactorily but there are fewer openings for technologists.

H. Rosemary Taylor (Mrs.) (*Associate*)
Greycot, Strines, Stockport, Cheshire.

* *Bulletin*, Vol. 8, (January, 1957) page 4.

† *Bulletin*, Vol. 8, (January, 1957) page 19.

THE INSTITUTE OF PHYSICS

CONSOLIDATED INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1956

1955 £		£
	To Office and general expenses :—	
14,087	Salaries and National Insurance and staff superannuation	15,860
4,565	Rent, rates, lighting, cleaning and maintenance	5,323
1,493	Postage and telephone	2,178
681	Travelling expenses, Board and Committee meetings	778
21,401	,, Production and distribution of publications (excluding cost of office labour and overheads)	19,051
2,082	,, Miscellaneous office expenses, printing and stationery	2,352
354	,, Bulletin (net)	1,527
2,093	,, Branches and Groups (including Australia) ...	2,499
134	,, Conferences and Conventions (net) excluding Branch and Group Conferences, overheads, labour, etc.	81
230	,, Educational work, examinations (net) and special reports	234
1,175	,, Miscellaneous expenses and House vote... ...	1,384
—	,, Repayment of contribution to X-Ray Fund for book	500
300	,, *Science Abstracts* basic payments	300
48,595		52,067
1,398	,, Decrease in stock of publications...	1,350
2,223	,, Surplus for the year before deduction for depreciation, etc.	3,898
£52,216		£57,315
359	To Amount written off expenditure on alterations, etc., to House	378
419	,, Depreciation of furniture, fittings and office machinery	1,205
985	,, Leasehold Redemption Policy Premium ...	985
460	,, Final surplus for the year	1,330
£2,223		£3,898

1955 £		£
29,175	By Receipts from publications	32,589
9,291	,, Receipts from advertisements in Journals ...	9,120
13,121	,, Members' subscriptions, entrance and application fees	14,033
419	,, Dividends and interest	640
210	,, Donations received by Trust Fund	157
—	,, Non-Members' conference fees	776
£52,216		£57,315
2,223	By Surplus brought down	3,898
£2,223		£3,898

THE INSTITUTE OF PHYSICS

CONSOLIDATED BALANCE SHEET, 31st DECEMBER, 1956

1955		
£		£
4,906	Life Membership Fund	4,832
17,433	Reserve Fund...	19,427
100	Endowment Trust Fund	345
2,000	Stock depreciation reserve	2,000
1,770	Mrs. Phillips' Bequest	1,770
	Current Liabilities :—	
6,243	Subscriptions to 1957 Journals and payments from members in advance	9,689
6,491	For expenses including production of publications	5,635
12,184	X-Ray Index Fund	16,960
£51,127		£60,658

1955			
£		£	£
	FIXED ASSETS :—		
	Furniture, fittings and office equipment at cost	6,023	
2,084	*Less :* depreciation	4,713	1,310
	Alterations, improvements and adaptation of premises, at cost	10,289	
6,515	*Less :* depreciation	4,152	6,137
	CURRENT ASSETS :—		
6,175	Stock on hand, at valuation		4,900
4,961	Debtors		6,869
12,294	Investments, at cost ... ... *(Estimated market value at 31st December, 1956, £10,787)*		12,279
5,910	Leasehold Redemption Policy		6,895
13,038	Bank balances and cash in hand		22,268
150	Endowment Trust Fund, Income and Expenditure Account—Balancf (deficit)		—
£51,127			£60,658

Vol. 8, April, 1957

The Teaching of Radioactivity in Schools*

By T. A. H. PEACOCKE, T.D., M.A., B.Sc.

(*St. John's School, Leatherhead*)

I AM ONLY a chemist but as I reflected on how best I could speak on this subject to physicists I remembered a remark of, I think, the late Lord Rutherford, to the effect that the greatest advances have always been made on the borders of the sciences. With this thought uppermost in my mind I took courage ; could not radioactivity be described as physical chemistry ?

I have been asked to consider how this subject can be introduced into the school syllabus. Perhaps some may question the wisdom of introducing it at all. The opponents will argue that we have enough to cope with already and that it is outside the examination syllabus. To this I would reply that a tree is improved by pruning and there is always dead wood to be cut out from our lectures. As to the second point, it is true that it is unlikely to gain many marks directly at present at "A" level, though questions on radioactivity occur in scholarship papers, but the interest aroused will well repay the time spent. Having thus, I hope, disposed of some of the objections, I will now put briefly the points in favour :—

1. The atomic energy program will need increasing numbers of nuclear scientists.
2. The applications of radioactivity in industry and pure and applied chemistry and biology make it advisable to introduce the subject early to the young scientist.
3. The fascination of the subject itself.

Before considering in detail how radioactivity should be introduced, it is necessary to mention certain difficulties which will be encountered, particularly at school level. These may be summarized as follows :—

- (i) Provision of the necessary detecting and measuring apparatus.
- (ii) Precautions with regard to health hazards :
  - (*a*) those due to external radiation,
  - (*b*) the possibility of ingestion.
- (iii) The provision of the necessary time.
- (iv) Contamination of apparatus and benches.

To take these points in detail :—

I. APPARATUS

For accurate quantitative work some form of scalar is an essential. A dekatron scalar can be made in the laboratory workshop by anyone with some knowledge of radio circuits. Failing this, a simple detector circuit can be used and it is even possible to do simple quantitative work with it. Several simple monitor circuits are also available.

II. HEALTH HAZARDS

To reduce these to the minimum students should always work with microcurie quantities and certain dangerous isotopes, such as Ca^{45}, Fe^{55}, Sr^{90}, Bi^{210} should be avoided. All α emitting powders should be treated with great caution and radioactive solutions must never be pipetted by mouth suction. For γ radiation from millicurie quantities or from neutron sources lead shields will be necessary and a pocket dose meter should be used. Students should not, in general, be allowed to handle such sources.

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* A lecture given to the Education Group of the Institute on April 5, 1956

III. TIME

This must remain a formidable factor. Careful choice of experiments will be necessary to fit these into the school timetable and the amount of time which can be devoted to the study of the subject will depend on the time allowed for science teaching. This must to a considerable extent determine the treatment.

IV. CONTAMINATION OF BENCHES AND APPARATUS

With the short-lived isotopes produced by neutron irradiation using an antimony-beryllium source there is no problem. You merely leave the apparatus to stand for a day or two and then it will be quite clear. With purchased radioisotopes on the other hand this presents quite a formidable problem requiring great vigilance on the part of the teacher. The benches should be covered with some impervious material such as glass, waxed or bituminized paper and all work with active solutions conducted in dishes. Apparatus must be rinsed with a suitable carrier after use and the method of treatment will depend on the chemical nature of the isotope. Soap can be most dangerous as it may precipitate insoluble salts firmly on the glass. Particularly is this so with P^{32}. Radioactive waste must not be poured down the drain except in very small quantities. Solid matter should be put in a labelled container and liquid in another labelled vessel to cool off.

THE APPROACH

This is a matter for individual choice but there would seem to be two principal methods, the classical or historical approach, or a direct introduction of radioactive isotopes. If the classical approach be chosen, then it could conveniently be introduced in a lower VI form and might well be applied to the study of the periodic system. In this connection I must recall the words of an eminent scientist who, when lecturing at Oxford in 1930, remarked: "There are 92 elements in nature. Ninety have been discovered. Two will never be discovered." At the time it struck me as a remarkably bold statement.

A course of some twelve lectures would cover the principal aspects of the subject. In this the student could be led through the classical experiments of Becquerel, to the nature of α, β and γ rays with a description of Rutherford's experiment with radon in which he detected the formation of helium in the course of the decay. Next he can be shown growth and decay curves which can actually be plotted in a few days using thorium B separated chemically from a thorium compound. This leads logically to the radioactive series, the thorium series being the simplest to study. Thorium C can be separated from thorium B using a bismuth carrier and the exponential equation verified by measuring its rate of decay, the half life of 60·5 minutes being fairly convenient.

These experiments can be supported by means of a cloud chamber—there are several types which can be constructed—and by decay in photographic emulsions, using nuclear research plates. These small plates, 3″ × 1″, should be soaked for ten minutes in a 1% solution of a thorium salt, left in the dark for a few days and then developed. A mass of stars will be found and suitable ones can be photographed through the microscope. Cosmic ray experiments can give great opportunities for those who are able to get their plates to a suitable altitude. The preparation of mosaic photomicrographs is good exercise in careful work for a boy with some experience of photography.

The course could be continued with a description of the transmutation of nitrogen by Rutherford using α particles, of the splitting of the lithium atom by Cockcroft and Walton and of the discovery of the neutron by Chadwick. This naturally leads to the production of artificial radioactivity by neutron bombardment. If a neutron source be available, and the antimony-beryllium source as supplied by Harwell is most convenient and comparatively cheap, a number of radio elements can be prepared. The neutrons emitted by this source are mono-energetic and only about 30 KeV. They can be thermalized by about 4 cm of water. Suitable radio elements prepared by neutron irradiation are Br^{80}, I^{128}, V^{53},

Mn^{56}, and Ag^{108}. These have conveniently short half lives and lend themselves to demonstration. Br^{80} and I^{128} can be obtained in high specific activity by Szilard-Chalmers reactions using organic halides. Mn^{56} can be separated from permanganate using a little manganese dioxide as carrier.

The course could be concluded by some explanation of the fission process, the operation of a uranium pile and the mode of action of the fission and fusion bombs. If time permits, some of the applications of radioactivity can be discussed such as uptake of ions by plants which can be easily demonstrated, with P^{32} or K^{42} and any seedlings, though tomato and chrysanthemum are generally supposed to be best.

Turning now to the design of practical work for the student, the main problem is the provision of the necessary apparatus. Apart from scalars and Geiger tubes, all the apparatus can be made in the lab. Even scalars can be constructed for a matter of £12–£16 by purchasing on the ex-Government market. Many of the experiments are comparatively simple and easily understood and can be carried out by students who are approaching or have passed their Advanced level.

The experiments can be divided into two categories. First, those which are devised to illustrate certain aspects of the subject itself. Secondly, those experiments which make use of radioactivity to illustrate points in more formal science teaching. It is here that the opportunities are considerable. We must, however, guard against over-enthusiasm. There is no object in using radioactive techniques when other simpler and possibly more efficient methods exist to do the same job. For the purpose of this discussion, it is convenient to divide the experiments into these two categories, i.e. those of a fundamental nature and those which we can describe as applications. My personal feeling is that the fundamental experiments are essential. We must not avoid the difficulties.

A suitable course of experiments would be the following :—

1. To determine the length and slope of the plateau of a Geiger tube.
2. A statistical check on a counter assembly. This is a most important experiment, both for checking the working of a newly constructed scalar, and for teaching the random nature of radioactivity and the magnitude of the statistical errors likely to be encountered.
3. An absorption curve for a pure β emitter. Tl^{204}, which can be obtained ready mounted from Harwell and has a half life of two years, is suitable.
4. Determination of half life for I^{128}, or V^{53}, by Szilard-Chalmers reaction. For this purpose a liquid counter such as a B6H is convenient and a neutron source essential.
5. Verification of the inverse square law for γ radiation. Co^{60} would be a suitable source.
6. To determine the half thickness of lead for γ absorption using I^{131}.
7. Separation of thorium B and thorium C from a solution of a thorium salt. This is a good introduction to carrier technique involving several precipitations. Lead and bismuth salts are used as carriers, the lead being separated as sulphate and the bismuth as sulphide or phosphate. If time permits the log activity of thorium B should be plotted against the time and this will show transient equilibrium, the activity growing initially with the production of the thorium C. To get satisfactory results the experiment must be carried out over a period of six hours, preferably for 24 hours.
8. Composite decay curves. These experiments can easily be performed using a neutron source and silver or rhodium. A silver half-crown gives excellent results, or a greater activity can be produced with a saturated solution of silver nitrate.
9. Nuclear isomerism. This is an advanced experiment and requires a considerable time to get the best results. Ethylene

dibromide should be irradiated with neutrons over-night and the Br^{80} extracted with dilute potassium bromide solution. Two isomeric states of bromine are formed with half lives of 18 minutes and 4·4 hours respectively. These yield a composite decay curve.

In conclusion may I outline a few experiments illustrating some applications of radioactive isotopes to physical chemistry.

10. Solubility measurements. Sparingly soluble salts such as silver chloride should be chosen. Apart from the e.m.f. method there is really no other satisfactory means of measuring these solubilities. Solubility products can be checked in really dilute solution and the relation between ionic strength demonstrated quantitatively. Ag^{110} is a suitable tracer though care is needed over the contamination of apparatus owing to the long half life (280 days).

11. Complex ions. The constitution of the silver ammine is an interesting study. This is an advanced experiment suitable for a scholar.

12. Distribution. The distribution law could be simple verified by using Br^{80} or Br^{82} or I^{131} distributed between water and an organic solvent. Both of the Br isotopes may be prepared with a neutron source.

13. Paper chromatography. Radioactive indicators afford one of the best methods of following this elegant technique. I am indebted to the isotope school at Harwell for this experiment. Potassium or sodium chlorides are irradiated in the pile for a week. One drop of a dilute solution containing 1 mg. of the mixture is chromatographed using Whatman No. 4 paper for speed. The eluent is methanol with 1% of concentrated hydrochloric acid. One hour's run is then sufficient. The resultant chromatogram can be analysed in two ways. One is by plotting a histogram. In this case the paper can either be cut into strips and each one counted or it can be attached to a rotating drum such as a clynostat with a slit in front of the counter. This saves at least an hour so that the experiment can all be done in 90 minutes. The second method is to use auto-radiography. Both should be used in conjunction. The results will be interesting and unexpected.

Finally may I say that to me one of the great attractions of this work is its freshness and the opportunity to link the sciences together. The novelty of the techniques has a markedly stimulating effect on the mind of both teacher and pupil. Much of the work can be presented in the form of problems. It will make great demands on the energy and time of the teacher, but I believe that it is worth it.

Degree and Diploma Courses in Applied Physics

(continued)

THIRD SESSION

Friday, November 16, at 10 a.m.

Chairman : D. B. BARTLETT, Esq.
(*Chief Education Officer, Southend-on-Sea*)
(*Chairman, London and Home Counties Regional Academic Board*)

Professor H. Lipson, F.Inst.P., F.R.S.
(*Professor of Applied Physics, College of Science and Technology, Manchester*)

INTRODUCTION

On general grounds, it may be thought that my claims to speak on the teaching of Applied Physics in Universities are firmly established in that I hold what is probably the only Chair in Applied Physics in this country. However, when my credentials are more closely examined, I am sure that my claims will not hold water ; with the best of intentions I have not been able to live up to my title, and I think that the reasons for this failure may well be worth discussing in this conference.

THE ORIGIN OF THE COURSE

When I took up my position as the Head of the Department of Pure and Applied Physics (to give it its full title) in 1945, the department was essentially a service department for the rest of the Faculty—the Faculty of Technology in the University of Manchester. At that time there was an extreme shortage of places in university physics departments, and in 1949 I proposed that my department, with staff and laboratories already available, should be allowed to help to alleviate the shortage. The Senate of the University of Manchester agreed and the course started in 1951 (incidentally when student pressure had decreased !). In order to differentiate the subject from that in the Faculty of Science, it was given the title Applied Physics. That is how the name arose.

The department did try to live up to its name, in the belief that it could provide a course significantly different from other physics courses, and yet with a content and intellectual stimulus of university standard. We proposed to concentrate essentially on classical physics, introducing, with the help of other departments, certain subjects which might enable our students to adapt themselves to industrial conditions more readily than students from more conventional departments. This aim still exists, but it is doubtful whether it justifies the name Applied Physics.

CONTENT OF THE COURSE

In the first place, it was necessary to devise a course appropriate to a university. It would, I think, be inappropriate to expand on this theme here, much as I should like to ; I shall therefore merely state that I believe that there is a tendency for university physics courses to deal rather too hurriedly with classical physics, in order to introduce as much as possible of the more exciting recent developments. Our aim therefore was to re-emphasize the importance of classical physics, at the same time introducing techniques and procedures that are useful to the practising physicist.

The main part of the course was therefore designed around formal mathematics and physics, and little need be said about these subjects. Some chemistry is introduced in the first year because physicists should know something about modern ideas on the nature of the chemical bond. In addition, there is a considerable amount of electrotechnics—both theoretical and practical ; physicists must have some acquaintance with electronics and they must also know something of the construction and operation of electric motors and the basic facts of electric supply systems. Some physicists have no idea what three-phase a.c. is until they meet it in practice with, perhaps, disastrous results ! Electrotechnics is therefore carried right through the course and is a subject in both parts of the degree examinations.

The techniques and procedures mentioned above provide what we may call light relief to the more serious lectures. There is, as we all know, a tendency to expand the content of courses to include as much as possible of modern knowledge, and many lecturers work on the assumption that the student has no other object in life but to understand their particular lectures. The poor student is thus passed from one class to another, with little time to *think* about the knowledge that has been dangled in front of him.

We have tried to solve this problem in two ways : first, we have deliberately left as much free time as we can in the time-table, so that, for example, students rarely have more than two lectures in any one day ; secondly, we have inserted periods for workshop practice and engineering drawing. It might be thought that these subjects are likely to turn students into technicians rather than scientists. I am quite sure that they do not ; the work is not pressed to its limits in the way it would be in an engineering department, and opportunity is taken of impressing upon the student the principles of instrument design and use so that he can grasp what *can* be done with materials even if he may not be able to do it himself. I am quite sure that a good physicist is made more useful with a background of this sort.

The workshop training is carried out in a workshop specially designed for teaching ; we are, I believe, the only physics department in the country with such a room, and it is extremely useful. It is used also by students from the Faculties of Science and of Education, and by certain non-university students. The third-year students and research students are also allowed to make free use of it for constructing any apparatus they may need.

OMISSIONS

It is obvious that we cannot add these extras without overloading the student unless some parts of physics are omitted. We have, therefore, deliberately omitted large portions of theoretical physics ; topics such as wave mechanics and relativity are touched upon only in so far as they impinge upon the understanding of practical developments. Nuclear physics is also treated in a general way, no attempt being made to compete with the more detailed course in the Faculty of Science.

The result of all this is that the student is provided with a course that, I think, is rather more leisurely than most, although whether it appears so to the student is another matter. But we try to obey the cardinal rule that there must be time for the student to ponder over his work, to discuss it with other students, and to take part generally in student activities. (Incidentally, the department has provided far more than its proportionate share of officials of the Students' Union.)

CULTURE

Cultural activities are difficult to fit into a technological course and I am not convinced that any direct attempt should be made to do so. I do not believe that culture can be forced down students' throats ; if they are interested in drama and ballet they will go to the theatre ; if they like novels they will read. Science itself is a form of culture ; it is as much a study of the impact of mind on mind as the humane subjects are, and no amount of lectures and displays will change students' tastes radically. The deliberately cultural side of the course is therefore rather small. The students have to attain a reasonable standard in German as a Faculty requirement for a degree. In addition they have to write essays—about one a term.

These essays, of length about 1,500 words, are taken seriously. The subjects are philosophical rather than factual, and they are severely examined with regard to content, form and style. Up to the present I have been mainly responsible for this work, but the growth of the department has necessitated its sharing-out amongst other members of staff. It may be argued that physicists are not competent to assess this aspect of a student's ability. I believe they are. Most physicists are able to recognize good writing when they see it ; to try to analyse this recognition is good for both the student and the lecturer. I admit that my standards are my own, and I am prepared to be told that *this* essay is poorly written. Any advice on its improvement will then benefit both me and the students I teach.

I believe that good clear writing is as important a physical tool as anything else that a physicist learns in a University.

EXAMINATIONS

Having put our students through the discipline outlined, how do we test them ? The examination content is fairly normal, with one exception : there is no practical examination for the final examination for the honours degree, but the student's work during the whole of the session is carefully followed and he has to present his practical notes to the examiners. The practical work has to be planned by the student : he can choose his work from a reasonably extensive list, he can build his own apparatus, and he can take any reasonable time for each experiment. He is allowed if he wishes to have two experiments running together, as we believe he often will have to do this in his future career and the sooner he gets used to it the better. (Incidentally, the word " he " should be taken to embrace both sexes. Although we have only a few women students, the number is sufficient to raise the proportion in the Faculty from ½ per cent to 1 per cent. We could do with more.)

In the middle of the second term the student is told that he must present an account of one experiment in complete detail—that is, in thesis form with proper diagrams and photographs. We believe that the preparation of this document is an important part of his training. On the basis of the total evidence, a mark equivalent to that for two written papers is allotted and included in the total for the examination.

We have every confidence in this procedure in spite of the general belief that the assessment of practical ability is too subjective to be of value. Of course, written work can be marked more-or-less objectively, but I think that few examiners would disagree with the view that it sometimes produces surprising results ! An industrialist recently said to me that he distrusts the first-class degree, preferring men with good second-class degrees. I think that he meant that he distrusts an examination system that takes only theoretical ability into account.

The five papers for the honours degree include three normal ones based upon lecture courses, one essay, and one on general physics. The last paper is designed to ensure that the student has carried out some reading and thinking outside his normal studies ; he must answer one question out of three on some general topic, and two out of four on some rather more elementary questions that call for certain physical insight. These last questions are set by the external examiner, and we are greatly indebted to our external—Professor J. G. Wilson of Leeds—who has entered so well into the spirit of this examination.

" APPLIED " PHYSICS

That, then, is a statement of what we are trying to do. Should the name " Applied Physics " be attached to it ? I think not. One envisages an applied-physics department as one with laboratories containing advanced technical instruments of the type that a practising physicist is likely to meet in his career—spectrographs, vacuum apparatus, high-tension equipment, and so forth. He could be trained in the use of such devices, but I submit that such a training would be technical, not scientific. With the time at our disposal we prefer to concentrate on fundamentals, hoping that our graduates will be able to adapt themselves rapidly to whatever branch of physics they are called upon to practise when they start on their careers.

So far, we have had only a few graduates and no general assessment of them is possible.

However, we ourselves are well satisfied with them as far as academic research ability is concerned ; the few students who have joined us in research can be compared with the students from other departments who have passed through our hands in the last ten years. On the whole, they stand up to this test well and we are completely satisfied that we are producing scientists, not technicians. We hope that the employers of our graduates, in whatever fields they enter, will share our views.

Professor M. R. Gavin, M.I.E.E., F.Inst.P.

(Professor of Applied Electricity, University College of North Wales, Bangor)

INTRODUCTION

The main purpose of this conference is to consider the types of course suited to the training of professional physicists and the ways, if any, in which the courses should be modified to suit modern requirements. In doing so we seem to imply that the content of courses is of prime importance, but we must not forget that an even more important factor is the quality and nature of the teaching. The student who learns his principles and habits of mind through contact with the right kind of teacher is indeed fortunate. I would go so far as to say that such a person trained as a chemist or a mathematician might ultimately be more successful in the field of industrial physics than a physics graduate who was less fortunate in his teachers. I am making this point to emphasize the limitations of syllabuses and courses unless they are allied to the right kind of teaching. It does not follow that we are wasting time in considering courses and their content. Although the intrinsic value of the subject matter of syllabuses is not great it is by no means negligible.

BASIC PRINCIPLES

In the training of the professional physicist there are two main requirements. The first is concerned with the inculcation of basic principles and the second is the acquisition of useful knowledge and techniques. The former is the more important and the more difficult, and I propose to consider it first. Our graduates, when they leave us, must be equipped with sufficient grasp of the principles underlying physical phenomena to cope with the progress and change which will occur during their professional lives. In the course of the next forty years or so there will be immense progress and change in our knowledge and understanding of physical phenomena. It is impossible for us to anticipate what revolutionary changes may take place, but we must try to give our graduates the understanding and mental attitude that will help them to keep up with these changes in whatever branch of science they pursue. This is a tall order and it is doubtful if we can hope to achieve it in many cases. In this connexion it seems to me to be essential that the graduate should have some appreciation of the logical basis of physics, namely, the assumption that there is an orderly world which obeys certain laws and that the purpose of physics is to try to find out what these laws are. The method of doing so is to observe phenomena and then to advance a theory to explain the observations. There is nothing, and here is the important point, intrinsically sacrosanct about a theory. It stands or falls by its ability to explain observations. There might have been less confusion during the last half century if this point had been better appreciated.

What should we teach in a physics course ? The foundation must lie on mechanics, electromagnetism and thermodynamics. The approach in the first place should be classical but this does not exclude the introduction of the ideas of atomic physics whenever feasible. The subdivision of physics into watertight compartments of mechanics, properties of matter, heat, light, sound, magnetism and electricity, atomic physics, nuclear physics, etc., may be convenient and to some extent unavoidable, but every effort should be made to link them together and to show the unity of much of physics. One might go so far as to say that the links between the branches are the essential basic principles that we are trying to teach. As simple examples we may take the common physical principles and mathematical relationships involved in wave motion in sound, radiation, hydrodynamics, wave mechanics, etc. ; or, in the concept of impedance in electric circuits, acoustics, vacuum technique, heat flow, radiation and magnetic circuits ; or, in oscillations in mechanical, electrical or atomic systems, in potential theory in its various aspects, in geometrical and electron optics and so on.

PHYSICS OF MATERIALS

As an example of the integration of basic principles over a wide range of subjects, I suggest that a new subject called the physics of materials should be introduced. Every industrial scientist is inevitably and intimately concerned with materials of one kind or another—solids, liquids, gases, metals, glasses, plastics, fibres, rubbers, semiconductors, ferrites, to mention but a few. It is frequently necessary to know or to understand or to test such properties as thermal or electrical conductivity, mechanical or electrical strength, hardness, corrosion resistance, response to temperature, etc. To meet these requirements adequately not only does the physicist need a good knowledge of his own properties of matter, but he also requires to know something of the engineer's strength of materials, some physical and organic chemistry, some metallurgy, as well as crystallography and the physics of solids. It is suggested that all of this should be integrated under the title, physics of materials. It may be rather difficult to find physics teachers sufficiently knowledgeable to do justice to this subject, and collaboration with the chemistry and metallurgy departments may be required. The final integration must be carried out in terms of atomic and solid state physics. Some attempt to develop a course of this type was initiated two years ago at the Birmingham College of Technology for the Sandwich Diploma students in Applied Physics.

This course might well be supplemented by some instruction in workshop practice, industrial techniques, instrument making and mechanical design. Some of the instruction in these more practical aspects might be better given in industry during vacation periods or graduate apprenticeship, or during the works periods of a sandwich course.

USEFUL KNOWLEDGE AND TECHNIQUES

The teaching of basic principles cannot be carried out in the abstract. Generalizations are reached through specific examples. In this way detailed knowledge is acquired and this may prove to be useful in itself. We may ask to what extent we should aim deliberately at giving useful knowledge. Obviously an industrial physicist will benefit from a knowledge of the common materials of construction and how they may be worked. At the same time it is desirable that he should have some acquaintance with the language of construction, engineering drawing. In the class of information which is generally useful we may include such things as the elements of power distribution, three-phase systems, simple properties of various types of electric motor. These are but a few examples from electrotechnology of the things which it is useful to know ; many others from different fields could be listed. If knowledge of this kind can be acquired in the course of learning principles so much the better. If not, we ought to consider if these things are sufficiently important to justify their inclusion in the course.

Engineering drawing and workshop practice are subjects which are included in the National Certificate Courses in Applied Physics. There is not a great deal of time given to them, but it is generally agreed that their inclusion is well worth while.

Much of the information which is classed as useful knowledge may be acquired from textbooks and reference books. Some time should be given to ensuring that our students know how to use reference books.

APPLIED PHYSICS SUBJECTS

In National Certificate Courses, in some of the technical college sandwich courses and in some university courses, certain applied subjects such as electronics, X-ray technology and vacuum technique are included. One of the main functions of this conference is to consider to what extent these are suitable subjects for the training of the industrial physicist. Their suitability must be judged in the light of the two requirements, viz. inculcation of basic principles and provision of useful information. In my view, provided these applied subjects are taught in the correct manner they have value on both accounts. In particular I would say that electronics is eminently suitable for teaching basic principles and it is also of considerable intrinsic value. It has the additional advantage of stimulating interest in the student. I have on a previous occasion listed some of the advantages of electronics as a means of teaching basic principles of physics. I repeat briefly some of these advantages. The subject of electrostatics is of fundamental importance but it is frequently considered to be rather dry and academic. In terms of electronic valves it is live and exciting. Systems of conductors become the cathode, grid and anode of a valve. Potential distributions and the relations between charge density, field strengths, potentials and potential gradients are well illustrated. Atomic physics and solid physics are all enlightened by the study of emission, semi-conductors, photocells, rectifiers and transistors. The behaviour of electrons in valves provides numerous exercises in basic principles of mechanics such as Newton's laws and conservation of energy. In the circuits associated with valves there are ample opportunities for the development of a.c. theory and transient theory. The general principles of positive and negative feedback may be established. In addition the subject provides ample scope for a great variety of fundamental laboratory experiments. When one adds to all this the fact that some knowledge of electronic techniques is practically essential in all laboratories to-day there seems to be an over-whelming case in favour of electronics both in its own right and as an integrating subject. In my opinion it merits much more time in a general physics course than, say, nuclear physics.

Similar cases might be made out for other applied physics subjects.

WHAT MAY BE OMITTED ?

If new subjects such as physics of materials and electronics are to be included in our courses we may well be asked what is to be omitted to make room for them. I think we should go over our time honoured syllabuses and judge each item on the two scores of basic principles and practical value. If we do and decide to omit anything that does not make some contribution on both accounts I think we shall find plenty of things that may be omitted. I do not propose to do this to any extent now but I have no great concern on this point. Some subjects may not be included formally in the course. For example, acoustics might appear incidentally in the integration process which has already been mentioned in subjects like wave motion, resonance, transients, etc.

LABORATORY WORK

The same yard-sticks of basic principles and useful knowledge and techniques must be used in assessing the value of our experimental work. A very large part of the time of an industrial physicist is spent in carrying out developments frequently of an experimental nature. As a preparation for this kind of work much of our laboratory training at the undergraduate stage is quite inadequate. I think that it is in this respect that there is greatest room for improvement. The neat, prepared experiment, frequently accompanied by a detailed instruction sheet, and every idiosyncrasy which the demonstrator has probably tried to eliminate—how far removed is this from a real experimental investigation. Experiments of this type done at the rate of one per day are the main parts of many laboratory courses. There is obvious advantage from the administrative point of view from such an arrangement and it does ensure that the student gets experience of a range of equipment. However, judged in the light of the inculcation of sound basic principles, it falls far short of requirements. Amongst these principles one would include not only knowledge and understanding of methods of measurement but also those vague but essential features of the good experimenter—critical outlook on his equipment, healthy scepticism, constant awareness of the required and the possible accuracy, sources of error (random and systematic) and their assessment. These qualities cannot be acquired easily, and only to a very limited extent from the prepared experiment. Here, even more than in the lecture course, is the actual syllabus largely irrelevant. Contact with the right kind of demonstrator is what really matters. Most of these good habits may be acquired equally well in any laboratory—physics, chemistry or engineering. In this connection I would like here to interpose some observations which may be relevant to the planning of new courses. In meetings of Boards of Studies to devise new sandwich courses or of Faculty Boards discussing new combinations for degrees, one frequently hears one head of department insist that he cannot do justice to his physics teaching unless he has four hours per week for lectures and six hours for laboratories. A second head of department feels just as strongly about chemistry but he needs five hours for lectures and nine for laboratories. Frequently they are dealing with the same poor student who may also have to fit in four or five hours for mathematics. In these demands for hours for practical work no allowance seems to be made for the benefits that should arise from the time spent in other departments. Unless a great deal of the skills and habits learned in one laboratory are of value in other laboratories there is something wrong with the course.

Some of the deficiencies of the formal planned laboratory course may be eliminated by the inclusion of suitable projects in which the students carry out assigned investigations on their own initiative.

MATHEMATICS

Before concluding I should like to make some comments on the teaching of mathematics. It seems fairly obvious that physicists or technologists study mathematics, not as an end itself, but to assist them in their study and understanding of their physics or their technology. Mathematics provides a valuable and precise language for the statement of thought. It is only in so far as the student acquires ability to use and to understand this language in relation to his own subject that the time spent on mathematics is justified. Mathematics is frequently taught as a mental discipline—as a quantitative logic divorced as far as possible from material things. This may be the correct way to deal with the subject with the student who specializes in mathematics. I am incapable of passing judgement on this point. But I am quite certain that for the science student mathematics should be a living subject constantly illustrated with real examples. Exponentials should be exciting functions of growth and decay—in electrical networks, atomic and chemical reactions, compound interest and biological growth and decay. This aspect of the subject should be welcomed by the mathematician and used fully and frequently to enlighten the significance of the mathematical processes.

There is one major criticism which I would make of many mathematics courses. They give little or no attention to the arithmetical and approximate methods of solution, though these are the only methods available in most practical problems. By all means let the mathematicians deal with their elegant methods like inversion and conformal transformations. But let them admit that real problems seldom yield to direct analytical methods, and approximate and experimental methods frequently have to be adopted. The greater the familiarity of the mathematicians themselves with these methods the better will they teach mathematics to scientists.

In case I may appear to be excessively critical of mathematics let me emphasize that I consider it of vital importance in the training of the physicist or the technologist. My sole concern is to emphasize that for the science student mathematics is essentially a tool and the object of the mathematics course should be to give him facility in the use of the tool.

A SANDWICH DIPLOMA COURSE IN APPLIED PHYSICS

In conclusion I would like to mention briefly two examples of courses in Applied Physics. The first is the Sandwich Diploma Course in Applied Physics at Birmingham College of Technology. This is now in the third year of the four year course consisting of alternate periods of six months in college and industry. The course was drawn up in an attempt to follow some of the principles discussed above.

1st Year	*2nd Year*
Mathematics	Mathematics
Physics	Physics
Chemistry	Chemistry
Workshop Practice and Drawing	Metallurgy
Glass Blowing	Electronics
Liberal Studies	Liberal Studies

3rd Year	*4th Year*
Mathematics	Mathematics
Physics	Physics
Electrotechnology	Instrumentation
Materials and Industrial Techniques	Physics of Materials
Electronics	Applied Physics subject
Liberal Studies	Liberal Studies

The entrance standard is advanced level G.C.E. in physics and mathematics, or a good Ordinary National Certificate in applied physics. The ultimate standard aimed at is that of an honours degree and it is hoped that successful students will gain the Dip.Tech. The chemistry, metallurgy, materials and industrial techniques in the first three years aim at giving the background knowledge of materials prior to the final integration under physics of materials in the fourth year. The practical or useful knowledge subjects, workshop practice and drawing, glass blowing and electrotechnology are included but it is possible that some of these subjects would be better covered during the periods in industry. Considerable time is given to laboratory work throughout the course and in the final year each student will spend at least six hours per week on a small research project.

So far only the periods in the college have been planned in detail. For maximum benefit from this type of course the time spent in industry should also be planned carefully with close collaboration between college and firm.

A UNIVERSITY COURSE IN APPLIED PHYSICS

Finally I give brief particulars of a course which is running at the University College of North Wales, Bangor. This is a three year honours course, in which the students study both physics and light current electrical engineering to pass degree standard, and then take honours in electronic engineering.

1st Year	*2nd Year*	*3rd Year*
Physics	Physics	Electronic Engineering
Mathematics	Electronic Engineering	Mathematics
Electronic Engineering	German	Servomechanisms
		Physics of Electronic Devices

This is essentially a course in applied physics with emphasis on the electronics side. In the final year each student spends twelve hours per week on a project on which he must submit a dissertation. The project and dissertation are given considerable weight in making the final award.

Similar courses combining physics and electrical engineering are offered in other universities.

DISCUSSION

Dr. D. G. Marshall (*The Dunlop Rubber Co. Ltd., Fort Dunlop*) *:* I was most impressed by Professor Lipson's account of his department, but I felt that it contained one notable gap, which I was pleased to hear Professor Gavin fill. I refer to the question of the physics of materials. I should like to support Professor Gavin's plea for a re-emphasis of this subject. Many graduates seem to regard Hooke and Newton as having been divine and Lamb and Love as having been their only prophets, but they find in subsequent life the appalling non-conformity of the vast array of actual materials. This experience is sometimes bitter and sometimes costly. I would make a plea for the occasional mention of such words as rheology and high elasticity.

Professor A. J. Woodall (*Royal Military College of Science, Shrivenham*) *:* I want to strike a note of urgency, because I do not think that we fully realize how much turns on the success of the marriage of the physicist and the engineer. (I am not thinking of Professor Lipson's problems with his women students !) Some of you may know the American publication called *Modern Physics for the Engineer*. If you have read that, you will know how in the United States this note has been sounded. It is pointed out that during the last world war the Americans had an enormous shortage of engineers but did not notice the deficiency because the physicists came forward. It was not that the physicist did the engineer's job, but when a physicist worked hand in hand with an engineer the results were much greater than those obtained from the two working individually. One of our great problems, therefore, is to train our physicists to work with engineers.

When we look at the degree courses which are being offered in this country, we see that there is a big tendency for us to be in watertight compartments. I am not encouraged by looking at what happens on the engineering side of the picture. In the case of the nearest and largest university, if you look through the revised regulations for the engineering degree you will see that the students can do mathematics in their first year, in their second year and in their third year, but no physics ; they leave physics at the intermediate stage, which means that all the rest of the physics that they have to learn they learn from engineers at second or third hand. If they later need physics, they say, " That is not physics ; that is engineering."

As there is no help from that side, we might look at what is happening on our own side. London has recently revised the syllabus of the general degree and the special degree. With the general degree there has been some bad staff work. The general degree has three subjects for the first year and two subjects for the two following years. The students in whom we are interested are those who will do physics and mathematics as their main option ; but if you look at the regulations you will see that the first year of physics starts only at ordinary level, but the chemists insist that they should start at advanced level, so that they go much further in chemistry. The special degree has been made much more formidable, and it will help to turn out better people for the academic side, but it will not help to turn out more physicists for industry, and that is a great pity. There is nothing in between the two ; nothing else is offered by London.

On the question of further training and postgraduate work, a disappointing note was sounded once or twice yesterday by those who said how little use the Ph.D. is. The Ph.D. course is supposed to be a training in research. There is a suspicion that there may be places in the country where the Ph.D. students exist only to glorify the department or the professor and that they are not being trained as they should be. I hope that that suspicion is unfounded, but if that is the explanation, that is something which should be looked into, because the Ph.D. course should train a man to stand on his own feet and do research.

Let me try to be constructive. I should like to see a degree of this kind. There should be two years of good, sound, solid physics, such as was spoken of yesterday, and then in the third year the student should be given options in which he can specialize. Let him have the intellectual joy of pursuing a subject as far as he is mentally capable of going. Let him go a long way in a few subjects, but make it clear to him that that is not the whole of physics. As a counterweight, give him also some applied work to do.

There are several ways of doing this, and I offer suggestions. One is that, if you have sufficiently courageous members of your staff, let them take groups of students and do their thinking aloud in their research, the students making criticisms and suggestions as far as they can, the research worker defending what he is doing, showing why some suggestions cannot be adopted, but accepting those which can be. That will require tremendous courage. There is a softer option for those who have not the pluck to do that, and that is to let the students tackle an applied problem, which may be a local problem, in syndicates. Then, if different syndicates attack the same problem, they can present their results and fight against each other. We have a good deal of experience at Shrivenham of syndicate work, though not in our degree courses, in which we are tied to London University regulations. We find that it is a very stimulating method of getting people to come to grips with a problem and for the cross-fertilization of ideas. We should make our degree students look at some applied problems, and then when they go for higher degrees or leave to take a job they will have had a taste of the type of problem they are likely to meet and how to get to grips with it, as well as some knowledge for its own sake. We might then have fewer people drifting into pure science who ought really to have been applied scientists, and vice versa.

Professor Blackett told us yesterday that our degree courses were all right and that we did not have to do anything about them, but when we look at the tolerance which he was prepared to put on this problem we find that it is wide, because he said that it did not matter much what we taught. If we accept that, then perhaps our degree courses are all right ; but I was disappointed by what he said. I had hoped for something more constructive. I do not agree that numbers are all that matter. If people are put through the wrong sort of course, not only in physics but in engineering, such as an engineering course with no modern physics in it, we shall be making a lot of dead wood for industry to cope with in ten or fifteen years' time, and to produce large numbers in that way would be bad.

Lastly, in the third year of my physics degree course I would put in something of scientific method. Some people would do it in other ways, because it is possible to teach people to think analytically without formal courses on scientific method, and it is the man who makes the method. Some scientists even say that there is no such thing as scientific method ; they seem unconscious of the principles which they practise. That reminds me of a recent incident when some young men went to their youth leader and said that they wanted instruction in German. He asked whether it might be a good idea to have first a course in English, to which the reply was " English ? Lor' lumme, guv'nor, what the 'ell are we talking now ? "

Mr. A. B. Calkin (*Mullard Ltd., London*) : I have been very impressed by what I have heard at this conference and find myself in agreement with much of it. I should like to underline some of the points which have been made. As an employer of university graduates our organization offers scope under three headings. First, in the research laboratories, where the work consists of fundamental research, applied research and advanced development. Secondly in the production side where there are some six different fields of activity suitable for graduates, viz. development and design, manufacture, quality control, test equipment design, applications engineering and the materials control. Thirdly, in the commercial department where physicists and electrical engineers are employed in small numbers on technical commercial work.

Professor Blackett told us yesterday of students' strong preference for research. That is exactly our own experience, and the reasons have already been stated in part. Research is considered as exciting ; it is a field which is familiar to the university graduate ; and probably more important still at the time that he leaves the university the graduate has little knowledge of the alternatives that exist. The opportunities in the manufacturing organization are to him at that time a closed book. Our main problem in recruiting graduates is to interest the large body of scientists that state a preference for research in the varied work of the production organization, for which both technically and temperamentally they may be better suited.

In an organization which is large enough to support a central research laboratory, one way of combating this reluctance of graduates to enter the production field is to offer employment initially in the research side of the organization, and to arrange for the transfer of a number of scientists each year from research into the various factories. By this means the production organization is fed with graduates who already possess specialized knowledge in the particular technologies involved, and recruitment as such is assisted.

I think that it was Mr. Burnett yesterday who, after talking about the opportunities for scientists in research and development, asked whether it would not be advantageous to use more scientists on production. The question which we have been asking ourselves over the last few months is, can we afford to use scientists in the production field, in view of the national shortage ? In trying to answer this question it is useful to consider the three main functional responsibilities of a section leader in the production department of a radio valve factory. Firstly, there is the responsibility for the quality of the product. Here it can be argued that, to carry this responsibility, the section leader must have a professional knowledge of the product and of the technologies involved in manufacture. Secondly, the responsibility for maintaining the planned output as laid down in the production program, involving as it does the organization of personnel and the supervision and maintenance of plant and test gear. Thirdly, the responsibility for keeping the cost of production within the budgeted allowance. These duties are partly technical and partly administrative, which suggests that, instead of employing a science or engineering graduate as manager of the section it might be practicable to employ an able but non-technical administrator who would delegate technical responsibilities to suitably qualified technologists. The question remains : is this likely to succeed in practice and thereby lead to the more economical use of science graduates ?

It is most important, in our experience, that scientists, whether they go into research, development or production, should also be good mixers. Research is no longer undertaken in isolation and project groups require people who can get on well together.

A final remark on the subject of quality and supply. By and large I think it would be true to say that we are reasonably well satisfied with the quality of the men that we are getting from the universities. Naturally, the quality of graduates from all universities is not equally good ; what is more important is that we need more of them. Here I support Professor Blackett's contention. Of course we should like more men with first-class honours degrees in research and in production, but as they are not available I feel that it is industry's job to make the best possible use of men with second and third-class honours.

Professor J. Greig (*King's College, London*) *:* I should like to express a reaction to the comments made by Professor Woodall. I recognize as of absolutely paramount importance the problem of facilitating the co-operation between the physicist and the engineer and I see in the detailed suggestions which have been put before us this morning a very valuable step in that direction. I regret that Professor Lipson has found some of his colleagues not quite so co-operative in that matter as he would have liked, but at least he found his electrical colleagues a little less unco-operative than some of the others.

What it is proposed to do in the physics course is to direct the attention of physicists to certain branches of physics which are of great practical importance and of great educational value, which are essentially fundamental physics and are perfectly acceptable as physics. To that is to be added what I might call a little smattering of engineering, and I do not use the word " smattering " in any derogatory sense.

If we turn to the engineering side, it is clear that we shall have to give our undergraduate engineers a smattering of modern physics ; but the point which I want to make is that we shall have to be extremely careful not to carry this smattering to the point at which the course is neither good engineering nor good physics. It is for that reason that I advocate for engineers a really serious introduction to the more recondite side of modern physics in the postgraduate course for the first-class honours men, perhaps five to ten per cent of the engineering output.

I think that we should also keep in mind that, whilst it is desirable for the engineers to do more physics, it is not necessarily practicable to introduce that extra physics at an early stage in the undergraduate course. The undergraduate has to learn his own subject not once but many times, each time re-learning it with greater depth and understanding. I take the view that a really serious introduction of modern physics to engineers is more a postgraduate than an undergraduate activity.

Dr. J. H. Davis (*College of Technology, Birmingham*) *:* Professor Woodall has given me a very good opening for what I have to say by his plea for some experience in experimental research for the undergraduate. He suggested that members of the staff should take groups of students, perhaps five or six, and let them have an inkling of what those members of the staff are doing in their research. We go very much further than that in the fourth year of our sandwich course in applied physics in Birmingham. There is incorporated in the course what we call a " project." What this means is that those senior lecturers who are themselves conducting research, either by themselves or with research assistants or research students working with them, will, as time goes on, sort out from their own work simple topics of an original nature which they can give to students in the fourth year of the sandwich course. These are topics on which the students will work for about five hours a week during four or five months of the last six months of the course.

The students are in the college only for six months at a time. They will be given the problem in writing, in a few sentences if it can be reduced to that, and may then be given a lead by the supervisor. In certain cases such a lead will not be necessary, while in others it will have to be fairly extensive and involve very close collaboration for the first few weeks, depending on the nature of the topic and the ability of the students. The student will then have to take his topic, look up the literature on it up to the present, which involves the use of *Science Abstracts* (which removes a deficiency commented on yesterday), and then have to design the method of obtaining the information required and present it in writing to his supervisor. When it has been approved, he will carry out the experimental work, have his results approved, and write them up in the form of a paper, initially for internal consumption in a bulletin which we are contemplating publishing, but the best work may perhaps lead to external publication. This sounds very ambitious but, on the other hand, with this project in mind and examining those students that we have already on the course, and some others who are not on the course but could have been, I feel confident that we have the material to do this type of work and students who can benefit by doing it.

Since I succeeded Professor Gavin I have not had sufficient time to go into the local industries and push the sandwich course, but I have approached one or two local employers and have found that, particularly in the research branches of those industries, there is some opposition to the sandwich course. Some of the research people seem still to prefer the external degree, with all its disadvantages, some of which have been removed by the new syllabuses. There was expressed by two or three individuals quite strong opposition to the sandwich course until I mentioned this project, when they became converted and welcomed it, because they saw that the project is something not included in the average degree course. We have in Birmingham considerable faith in it, and those of us who are doing research are keeping our eyes open for suitable topics. We always know three years ahead the maximum number of people that we shall have on these projects in a particular year.

On the question of the number of hours, at present the students do twenty-seven hours a week in actual contact with the teaching staff in the laboratory or lecture theatre. This, I consider, is excessive, and I want to cut it down, particularly in the third and fourth years, but cutting it down presents a problem. We can always see ways of extending the course up to seventy hours a week, but it is very difficult to cut out four or five hours and substitute private reading time, which is, of course, extremely important.

I wish to make a comment which I hope that the industrialists here will bear in mind. I was approached in the beginning of September by a local firm who have a student, one of their workpeople, who was a student with us and a very capable lad, and who obtained very good results in the examination which he took. They said to me: "Why do you not put him on the sandwich course?" I said that I would certainly do so, and that I had already considered asking them if they would allow him to enter. They said: "We will consider it ; send us all the details," and I did so. The result was not what I expected ; they wrote back : "This is excellent, and we should like to put this man on the sandwich course, but unfortunately we are a small firm "—I knew that to be true—" and so poor "—which I suspected might be true—" that we cannot afford to release him for six months and employ somebody to replace him." That problem faces a number of small firms in the Birmingham area. What we should do about it I do not know, but it is a very real problem, and we are losing some very good material for that reason.

Mr. J. Brosgall (*Southern Regional Council for Further Education, Reading*) *:* I have some contact with industry in a consultative capacity, and I should like to follow up what Mr. Calkin said. It is the industrial requirement, I think, which has stimulated the greatest interest in this conference. The general desire, as expressed by one representative of industry after another, is for the more able graduate in physics, but we have also to make the best use of those who are less able.

Representatives from industry have complained that when men come from the university they are very rarely, if ever, of immediate use in industry ; and anything which tends to improve their usefulness from the start is worth trying. Someone suggested yesterday that a fourth year seemed to make people more useful. Professor Blackett said that a fourth year for scientists at the universities was impracticable ; the cost would be too great. We have here representatives both of the universities and of the technical colleges, and I wonder whether we might consider another way of providing a fourth year.

The better graduates will tend to do research at the universities, but we need to consider those graduates of less ability who at the moment enter industry with rather less equipment than one would wish. Would it not be possible for them to take either a full-time course of a year, or perhaps a sandwich course, at a technical college, in order to secure that contact with and knowledge of other subjects which everyone has agreed are so useful in industry ? The technical colleges would probably have to be selected for the purpose, because special subjects would be necessary for those going into the aeronautical industry, or electronics, or the metallurgical industry. These selected colleges could provide postgraduate courses in industrial physics which would enable graduates to acquire something of the outlook and techniques which are characteristic in industry.

Mr. K. A. Macfadyen (*University of Birmingham*) *:* I have been struck by the fact that all the courses discussed at this conference are of similar intellectual standard even though they may differ somewhat in emphasis. The large number of failures in the last Institute graduateship examination suggests that there ought perhaps to be more suitable training and recognition of people with somewhat lower intellectual attainments. There is little doubt that such people could profitably be absorbed into industry ; they would fill the rather wide gap between the graduate and the technician.

It may seem presumptuous to question the views of so experienced an administrator as Mr. Humphreys, but the plan of appointing an administrative head as well as a scientific head to a group is fraught with the danger that direction will generally tend to pass to the administrative head, to the dissatisfaction of the other. This situation has been skilfully described in Nigel Balchin's *Small Back Room.*

Mr. D. B. Bartlett : I now ask Professor Gavin and Professor Lipson to add their own comments in the light of the discussion.

Professor M. R. Gavin : So many points have been raised that I shall not attempt to deal with them in any detail, but I wish to take up the point made by Mr. Macfadyen. This conference, as I understand it, is aimed at the discussion of degree and sandwich diploma courses, which are intended to be something approaching degree standard ; the entrance qualification which is being asked for in each case is two advanced level subjects or their equivalent. The man who spends four years part-time, with six months in college each year, must reach something approaching honours degree standard. That does not necessarily mean that these courses will produce the same type of person, though they may do so to some extent. The bias on the sandwich type of course, I think, will be more towards the man in industry who is going to be concerned largely with the high grades of development, as distinct from the man who is going to be in research. Men should be recruited from the university for research and from the technical college for high-grade development.

There is, however, a wide field which we have not attempted to discuss at all—all the people who form the background army to carry out most of the work on which the others will depend. This field is catered for at the moment, to some extent by the national certificate courses. The Institution of Electrical Engineers recruits very many of its professional members through courses of that type, and The Institute of Physics also recruits quite a number in that way. That type of course, or possibly a modification of it to bring it more into the lines of a sandwich course, might be worth thinking about. There are also lower levels. There are the City and Guilds technical courses, which are extremely good of their kind and can produce very valuable people for what are very important activities in industry, apart from the professional people who have been the main subject of this conference.

In connection with the sandwich courses, there is one point which I want to add to what Dr. Davis said on the question of projects in the final year of the sandwich course. They are a very important part of the scheme. This is another way in which there might be collaboration with industry. If a project could be obtained from the man's own industry, so much the better. It should preferably be under the control of the college. On the question of hours for sandwich courses, I am most heartily in agreement with Dr. Davis. The course which I described is very much overloaded, and in considering what is going to be left out I would strongly recommend consideration of the fact that the detailed content of most of our courses is intrinsically not of very much value. We could leave bits of it out without great sacrifice provided the men have learned the right principles and the right habits of mind and have been in contact with the right people. These courses are all dependent on the people who run them and will be coloured by the interests of the senior staff in the various colleges. It is right that they should be ; people are much more likely to teach really well on the subjects in which they are interested and which they know something about.

Professor H. Lipson : I should like to correct any impression which I may have given that the other departments in the college were not co-operative. I think I did say that they were co-operative. If anything, they were too co-operative ; they tried to insinuate that they knew better what we wanted than we did ourselves. When we put forward new ideas in mechanical engineering, they allowed one of their lecturers to co-operate with one of ours to produce a course. They may adopt something of the kind in their own department. Both the mechanical and the electrical engineers were extremely co-operative.

On a larger point, I would ask you to remember two fundamental facts in teaching. They certainly apply to my own department, and I think that they both apply to all other departments. The first is that the staff are human, and the second is that the students are human. We get the students at the age of eighteen or so, fresh from school, and we have them for three years. In that time some people seem to expect that we shall turn them into complete men of the world. It is impossible. We do our best, but we pass them on to the industrialist in the full knowledge that their training is quite incomplete ; but we pass them on at that stage because we think that for certain people it is the best age to pass them on. Others we like to keep on for research, partly because it helps the department and partly because it helps them.

That brings me to the question of the fourth year and the suggestion that the students would be much better if we had them for another year. I would state very forcibly that I am against the fourth year. I think that I am in a minority in saying this, having discussed it with a number of other departmental heads, but I do not believe that there would be any appreciable difference in our products, except such as are incidental to having them for an extra year, one being that they will be a year older.

In teaching physics to students it is not possible to cope with more than a small proportion of the total content of physics. Everyone agrees with that. If we had them for a fourth year we could cope with a little more than is possible in three years, but it would not make a fundamental difference. Our main contribution is not so much in what we put into the students as in our assessment of their abilities. In two years we train them in fundamental principles, and then we get some idea of what they are like, and can say that this man is first class, this man second, this third and this very ordinary. I think that that is a most useful contribution. At the end of two years we begin to have ideas, and the third year fixes those ideas more firmly. There are many intelligent laboratory boys who can tell a student at the beginning of his third year what kind of degree he will get. I do not think that the laboratory boys would be any more right if we had the students for a fourth year.

Dr. J. E. Richardson (*Northampton Polytechnic, London*) *:* I take it that my task is not to repeat what has been said, or even to pick out those things which have been said most often and say : "That is the point at which we have arrived." It is important, however, to ask ourselves what point we have reached.

I have been trying to do just that, and I find I have reached a large number of negatives. Perhaps that is not a bad position to reach. Yesterday Professor Blackett told us that many things were self-cancelling, and that is still true to-day.

Going back to yesterday, we discovered that more and more physicists or applied physicists were needed. We knew that before we came here, because the White Paper told us so. The universities seemed to be largely satisfied with what they were doing. There has been throughout the conference a very strong emphasis on the need for fundamental physics, sometimes called classical physics. We appear to have learned from industry the fact that they need a great many supermen, that the colleges were not capable of supplying them, but that they will do their best with the men the colleges do turn out in the hope that these men may be all right in the end. There has been some discussion on the place of culture or liberal studies, and whether they should be included or not. I think that these arguments also have been self-cancelling so that we have not got very far there either.

Have we got anywhere definite this morning ? We have not reached any resolution on the type of course that we need or on the details of what should be provided in such a course. It is apparently conceded, however, that something is needed, and we were told by Professor Blackett yesterday that there was scope for a good deal of experimentation and variety. We have not reached any prototype pattern, and perhaps that is all to the good.

I did detect, however, a strong feeling that applied physics should be postgraduate, though we have had a suggestion this morning for an undergraduate course. In my college we tried to do something in a field of activity which is of increasing importance to-day, that of instrument engineering. The instrument technologist is increasingly required for all the instrumentation which is going into industry, and we noted that physicists were being recruited for this kind of work and oriented to their new task. We therefore put on a nine-month course, and informed a large number of industrialists of this and suggested that it would save them time and trouble if they would send men to us for this period. In the first year we offered the course we had only two applicants ; in the second year we had four, and actually started the course, but one man dropped out at Christmas. This year we have had none. I would therefore urge industry to take some notice of the provision made and see whether or not there are courses in the universities and technical colleges which would fill the bill.

We have had descriptions of three courses which are actually in existence. Yesterday Professor Rankin told us about his course at Glasgow, and this morning Professor Lipson and Professor Gavin have described what they are doing. I am not sure what these mean to the conference, but probably Professor Rankin's is the most significant to us, because it has been going for a sufficiently long time for the products to have gone into industry and for industry to say: "We like these people ; give us more of them." Professor Lipson's course has not been established long, and Professor Gavin left before industry discovered what the products were going to be like ! It may be, however, that as there is no agreement as to what should be done there is still room for experimentation.

We have not discovered any clear division of interest and responsibility between the universities and the technical colleges. As a technical college man I am very glad of this since it means I can still experiment in the university field !

There has been a good deal of emphasis on the quality of the teachers and also on methods of teaching. We were reminded yesterday, and again this morning, that quality of mind is an outstanding need. I liked the remark " industry wants minds, not memories."

Some discussion has taken place on the right length of course, or at least on the number of hours per week and on the content of the course. It has been suggested that the twenty-seven hours a week required for one course which has been described this morning is too long. If it is too long, the question arises as to what should be taken out without serious loss. Yesterday's discussion on liberal studies was a little indeterminate, and to-day Professor Lipson himself referred to the contribution which could be made by the students in their own activities. I do not know whether or not the conference would agree that the right answer to the double problem of duration and content might be to cut out all the liberal studies and liberalize the rest of the studies.

Another point raised was the cost of sandwich courses, especially to the smaller firm. I think this is of great importance and here I should like to make a contribution, rather than a summary of what has already been said. This has been a matter of concern to me for a considerable time. I think we are making a very great mistake to-day in pushing all the financial responsibility for this type of training on to industry. At present industry can lift off a peg its B.Sc. Physics man and may be able, in a year or two's time, to do likewise with the B.Sc. Applied Physics man at no cost whatever directly to itself. On the other hand, with sandwich courses, industry has to pay the full cost. It is expected to pay the man while he is at work and while he is at the college, and in many cases to pay the cost of the instruction as well. As soon as there is the merest breath of a trade recession, industry will be bound to say: "We shall have to stop these courses ; we cannot afford them any longer." We have been told that some firms can hardly afford to send a man on such a course to-day ; when the slightest hint of a recession comes, they certainly will not be able to afford it. An industrialist known to me wishes to send eighty students to a college. The estimated cost of training each student will be £2,000, and 80 × £2,000 is a great deal of money. I think the local authorities ought to be responsible for the full maintenance of the students during their six months in the college. Relief such as this will help industry considerably and especially the smaller firms. It will help to ensure the success of sandwich courses generally and in particular it will help the colleges to keep in being courses such as these applied physics courses.

The great merit of this conference is the bringing together of the educationist and the industrialist for a mutual exchange of views. It is probably no bad thing that no very specific resolution of one sort or another has emerged.

Finally, I think that the whole conference will wish to thank Professor Lipson and Professor Gavin for the way in which they have prepared their papers and presented them to us.

The Institute's Journals

PRINCIPAL CONTENTS OF THE APRIL, 1957, ISSUES

Journal of Scientific Instruments: Volume 34, No. 4

CONFERENCE REPORT

Summarized proceedings of a conference on contemporary optics. Sydney, 1956.

A conference on contemporary optics was held by the Australian Branch of The Institute of Physics in Sydney on 19, 20 and 21 September, 1956. The conference was opened by Dr. F. W. G. White, President of the Australian Branch, who pointed out that the conference served to demonstrate the strength of optical research in Australia, where there have been major post-war developments in interferometry and in geometrical, physical and instrumental optics. The papers presented are summarized in this report.

ORIGINAL CONTRIBUTIONS

A high temperature microfurnace for the study of the devitrification of glass. By H. Bridge, A.Inst.P. (*Pilkington Bros. Ltd., St. Helens, Lancs*).

The construction and operation of a microfurnace designed to combine a low thermal capacity with accurate temperature measurement is described. The specimen, which is approximately 1·5mm in diameter, may be raised to a temperature of 1200°C in less than one minute and maintained to within ±2°C of the working temperature for several hours. For general work the specimen is viewed with a ×5 objective, through a ×10 objective, with a numerical aperture of 0·25, may be used for continuous observation up to 1,000°C and for shorter periods at higher temperatures. In the instrument described the specimen is exposed to the air but conversion for work in a controlled atmosphere would be relatively simple.

Though primarily designed for the study of crystal growth from the melt, and the rapid delineation of phase equilibria diagrams, the apparatus has been applied to the study of the growth of single crystals, melting-point determinations and the investigation of phase precipitation in opal glasses. Special attention has been given to the photographic recording of experiments and an example of rate of crystal growth measurement using this technique is given.

A photographic recording microphotometer. By J. Bor, F.Inst.P. (*West Ham College of Technology, London, E.16*).

A simple method of converting a non-recording microphotometer into a single-beam recording instrument of good discrimination and high speed is described. The existing photovoltaic cell of a Hilger microphotometer is replaced by a cadmium selenide photoconductive cell. This increases the sensitivity to such an extent that the long period galvanometer is replaced by a much less sensitive, more robust, and very short period galvaometer. By connecting a large ratio reduction gear between the plate slide of the microphotometer and a large photographic drum the instrument is converted to a recording microphotometer of good discrimination, large magnification and high speed, capable of handling a wide range of photographic densities.

The floating-zone melting of refractory metals by electron bombardment. By A. Calverley, M. Davis and R. F. Lever (*Services Electronics Research Laboratory, Baldock, Herts*).

An apparatus which produces floating liquid zones in vertical rods of refractory metals is described. Movement of the zone along the specimen can purify it in three ways, namely, outgassing on vacuum fusion, evaporation of volatile impurities, and segregation of impurities in the liquid zone. Traversing speeds of approximately 1cm/min have been used and the vacuum maintained between 10^{-5} and 5×10^{-4} mb. Power requirements are about 400 W or less. There is a theoretical upper limit of approximately 1 cm on the diameter of a specimen and a practical size limit on its length. Specimens as low as 2 mm in diameter have been zoned. After zoning, many specimens are found to be single crystal.

Mercury-in-quartz thermometers for very high accuracy. By H. Moreau (*Bureau International des Poids et Mesures, Sévres*), J. A. Hall, F.Inst.P., and Vera M. Leaver (*National Physical Laboratory, Teddington, Middlesex*).

Experiments have shown that mercury thermometers of fused quartz do not show zero changes exceeding one or two hundredths of a degree after heating to 600°C, while heating for a month at 100°C did not produce a change greater than 0·001°C. Thermometers and observing equipment have been designed to take advantage of this stability, and observations on a thermometer ranged 0° to 28°C show a reproducibility of reading to within ±0·0007°C over a period of twelve months.

The measurement of the momenta of high energy charged particles in a diffusion cloud chamber. By B. B. Culwick (*Department of Physics, University of Birmingham*).

The problems associated with the measurement of the momenta of high energy nuclear particles in a diffusion cloud chamber are described. An optical system has been developed for which the apparent curvatures in the object due to distortion have an average value of 0·005m^{-1} over the field of view. Spurious track curvatures due to convective gas motions within the cloud chamber are of similar magnitude, when a flash delay time adequate to allow the photography of the tracks of minimally ionizing particles in hydrogen is used. Those figures result in a nominal accuracy of about 2% in the momentum of a 1,000 MeV proton (momentum $1{\cdot}7 \times 10^{9}$ eV/c) in a magnetic field of $1{\cdot}3 \times 10^{4}$ G for tracks 20 cm long. The corresponding maximum detectable momentum is $8{\cdot}5 \times 10^{10}$ eV/c.

LABORATORY AND WORKSHOP NOTES

NOTES AND NEWS

NOTES AND COMMENTS

INSTRUMENTS, ELECTRONICS AND AUTOMATION EXHIBITION—A PREVIEW

British Journal of Applied Physics: Volume 8, No. 4

SPECIAL ARTICLE

The analysis of finite-length records of fluctuating signals. By M. J. Tucker, A.Inst.P. (*National Institute of Oceanography, Wormley, Surrey*).

The problem discussed is that of estimating the characteristics of a signal from a record of finite length by Fourier-type analysis or by direct measurement. The paper is an attempt to present the fundamentals of the problem in a coherent form and with the simplest possible mathematics : the results given are not new. The main discussion is of the accuracy of estimates of the power spectra and r.m.s. amplitudes of stationary random Gaussian processes : these have the characteristics of filtered random noise and include a class of signals of great practical importance. The arguments also apply to the problem of estimating the maximum speed with which a signal can be measured and analysed directly.

ORIGINAL CONTRIBUTIONS

Variations in tension of an unwinding thread. By K. H. V. Booth (*Birkbeck College Computational Laboratory, University of London*).

The variations in tension occurring as a thread is pulled with uniform speed from a cylindrical spool are considered. For simplicity the steady state case when the thread follows a curve of constant shape on the surface of the spool is taken. It is shown that there is a limiting value, depending on the tension of winding and speed of the thread, for the angle with which the thread leaves the spool. Curves are given from which it is possible to estimate the variations in tension as the point of unwinding moves up the spool surface.

Transverse vibrations of power transmission chains. By S. Mahalingam (*Department of Applied Mechanics, University of Sheffield*).

In this paper the natural frequencies of a travelling chain are determined by treating the chain as a uniform string. For a constant chain tension the natural frequencies decrease progressively to zero as the chain speed approaches the velocity of transverse wave propagation. In practice such a condition is not obtained since the chain tension increases with speed owing to centrifugal effects. Formulae are obtained for the amplitude of forced vibration of the chain when excited by a transverse displacement at one end. The effect of damping is considered and exact and approximate methods of determining resonant amplitudes are given.

The effect of sulphur and oxygen on the electrical properties of oxide-coated cathodes. By G. S. Higginson (*Physics Department, University College of North Staffordshire*).

Poisoning and recovery experiments using both oxygen and sulphur substantiate the Loosjes and Vink theory of conduction. Sulphur is found to have a greater poisoning effect than oxygen. A possible reason for this is suggested.

Some carbon replica techniques for the electron microscopy of small specimens and fibres. By D. E. Bradley (*Associated Electrical Industries Ltd., Aldermaston, Berks*).

The difficulties encountered in making replicas of fibres and other small specimens are discussed, and three carbon replica methods are described. The first is designed specifically for fibres. The tedius partial embedding techniques which have hitherto been required for such specimens are eliminated. The second method is for small specimens which are difficult to handle and range between about 0·5 and 2·0mm in size. It has not been possible to use conventional methods with these specimens. The third method is for soft biological specimens such as bacteria. Existing single-stage replica techniques failed with such specimens, largely because of the strong chemical reagents required to dissolve the organic materials. All three methods are illustrated by various applications.

X-ray diffraction studies on precipitates and inclusions in steels using an extraction replica technique. By G. R. Booker, A.Inst.P., J. Norbury, F.Inst.P., and A. L. Sutton (*R.T.S.C. Laboratories, Whitchurch, Bucks*).

A simple extraction method is described in which precipitates and inclusions in steels can be isolated for identification by X-ray diffraction. The included material is removed from the metal surface embedded in a thin plastic replica, which is then formed into a small, compact, cylindrical specimen suitable for powder cameras. The scope of the method is discussed, and examples of the application of the method are given. Because the extraction period is only a few minutes, the method has several advantages over bulk extraction methods. In addition to the more stable constituents, iron carbide, iron nitrides and metal sulphides have been successfully extracted.

On the mathematical theory of zone-melting. By I. Braun and S. Marshall (*H. H. Wills Physical Laboratory, University of Bristol*).

A complete solution is presented of the equations governing the redistribution of solutes in zone-melting processes. The effect of " normal freezing " in the last zone-length of a bar is treated rigorously. The solutions hold for all values of the distribution coefficient *k*. Numerical calculations have been made of the concentration profiles resulting from repeated zone-melting, and specimen graphs are given.

A method for the measurement of heat generation in powdered coal. By P. C. Newman, A.Inst.P. (*National Coal Board, Stoke Orchard, Glos*).

A new method is proposed for measuring the generation of heat in coal or other finely divided powders. This method depends only on the thermal constants of the material and not on the heat losses to the surroundings of the calorimeter.

New solutions to the heat flow equation for heat generation in cylindrical and spherical bodies as required for calculating the results are presented, and experimental confirmation of the suitability of the method is obtained. During the course of the work, an interesting result is obtained on the critical sizes of systems which generate heat at a rate which increases linearly with temperature.

A study of aircraft response to sudden and graded wind gusts by means of a differential analyser. By W. R. Blunden, A.Inst.P. (*Australian Military Forces Military Board, Melbourne*), F. H. Hooke (*Aeronautical Research Laboratory, Australian Department of Supply, Melbourne*) and H. K. Messerle (*Electrical Engineering Department, University of Sydney, Australia*).

The solution of the " gust " problem for a range of parameters, sufficient to give results that would be useful to designers, is not practicable without the aid of an automatic computer. This paper describes the assumptions made for a detailed analysis on a mechanical differential analyser and the results obtained are summarized. Some discussion is given on the speed and accuracy of the solutions obtained.

NOTES AND NEWS

NEW BOOKS

NOTES AND COMMENTS

Forthcoming Institute Meetings

April 16 Scottish Branch
In the Carnegie Laboratory of Physics, Queen's College, Dundee, 5.15 p.m.
" *Microscopical Investigations of Fresh Cells* "
DR. E. M. F. ROE
(Chester Beatty Research Institute, University of London)

April 25 Midland Branch At Regent House, Birmingham, 7 p.m.
" *The Strength of Metals* "
DR. A. H. COTTRELL, F.R.S.
(Atomic Energy Research Establishment, Harwell)

April 26 South Wales Branch
At the University College of Wales, Aberystwyth, 5.30 p.m.
" *Instrumentation of the Liverpool Synchrocyclotron* "
DR. B. COLLINGS
(University of Liverpool)

May 10 Liverpool and North Wales Branch
In the Department of Electrical Engineering, University of Liverpool, 6.30 p.m.
Branch Annual General Meeting Tea 6 p.m.
followed by
" *Rocket Exploration of the Upper Atmosphere* "
PROFESSOR H. S. W. MASSEY, F.R.S.
(University College, London)

Physical Society Meetings

Members of the Institute are invited to attend the following meetings of The Physical Society:

May 1 Colour Group
" *Colorimetry and Colour Photography as applied to Natural Phenomena* "
MR. N. GADSDEN

" *Properties of Extra-foveal Vision* "
MR. F. J. J. CLARKE

" *Effects of Steady Fixation on Colour Matching* "
MR. K. J. MCCREE

At Imperial College, at 3.30 p.m.

May 2 Optical Group
" *Protective Coatings for Thin Films*
MR. L. HOLLAND AND OTHERS
At Imperial College, at 2.30 p.m.

May 2 Low Temperature Group
" *Cyclotron Resonance in Metals* "
DR. R. G. CHAMBERS

At the Royal School of Mines, at 4 p.m.

Report of the Board of The Institute of Physics for the year 1956

TO BE PRESENTED FOR ADOPTION AT THE ANNUAL GENERAL MEETING OF THE INSTITUTE ON JULY 12, 1957

The Board and its Committees

The present Board took office on October 1, 1956 ; its members on December 31, 1956, were :

President : Mr. O. W. Humphreys.

Immediate Past-Presidents : Dr. C. Sykes, Sir John Cockcroft.

Vice-Presidents : Mr. G. R. Noakes, Dr. W. H. Taylor, Dr. B. P. Dudding, Professor E. A. Owen.

(Professor E. A. Owen was appointed by the Board under the powers conferred on it by Article 55 for filling casual vacancies.)

Honorary Treasurer : Dr. J. Taylor.

Honorary Secretary : Professor F. A. Vick.

Ordinary Members of the Board : Dr. P. S. H. Henry, Dr. M. R. Hopkins, Dr. J. M. A. Lenihan, Dr. K. A. G. Mendelssohn, Mr. A. T. Pickles, Mr. H. P. Rooksby, Dr. L. R. G. Treloar, Mr. G. W. Warren.

Chairmen of Branches in Great Britain : Professor E. A. Owen (Liverpool and North Wales), Dr. J. S. Forrest (London and Home Counties), Dr. R. W. Sillars (Manchester and District), Professor P. B. Moon (Midland), Professor W. E. Curtis (North-Eastern), Dr. J. M. A. Lenihan (Scottish), Professor R. M. Davies (South Wales), Professor W. Sucksmith (Yorkshire).

Representing The Physical Society : Dr. H. H. Hopkins and Mr. A. J. Philpot.

During the year the Board met six times and appointed the undermentioned Standing and Executive Committees which held ten meetings.

Finance and General Purposes Committee (Chairman : The Treasurer).

Membership and Examinations Committee (Chairman : Dr. W. H. Taylor).

Benevolent Fund Committee (Chairman : Dr. J. Taylor).

Advisory Committee of the British Journal of Applied Physics (Chairman : Dr. R. W. Sillars).

Advisory Committee of the Journal of Scientific Instruments (Chairman : Dr. K. A. G. Mendelssohn).

Third Convention—Oxford, 1957 (Chairman : Dr. B. P. Dudding).

Representatives and Nominees on Joint Committees and other Bodies

The Institute has been represented as follows and summaries of the principal work of those bodies likely to be of interest to members are given in the appendix to this Report.

On The Royal Society's National Committee for Physics : Prof. F. A. Vick.

On The Royal Society's National Committee for Crystallography : Dr. W. H. Taylor.

On The Royal Society's Paul Instrument Fund Committee : Sir Frank Smith.

On the Board of The British Nuclear Energy Conference : The President, Sir John Cockcroft, and Dr. H. R. Lang.

On the Joint Council of Professional Scientists : Prof. F. A. Vick, Dr. J. Taylor, and Dr. H. R. Lang.

On the Parliamentary and Scientific Committee : Prof. F. A. Vick and Dr. H. R. Lang on the General Committee, together with Dr. J. S. Forrest and Dr. J. Taylor at the Annual Meeting.

On the Committee of Management of Science Abstracts : Dr. L. R. G. Treloar.

On the National Council for Technological Awards Board of Studies in Technologies other than Engineering : Prof. F. A. Vick.

On the City and Guilds of London Institute's Advisory Committee on Courses for Laboratory Technicians : Mr. N. Clarke, Mr. T. H. Tyler and Mr. L. Walden.

On the City and Guilds of London Institute's Advisory Committee on the Training of Instrument Mechanics and Technicians : Mr. N. Clarke.

On the City and Guilds of London Institute's Advisory Committee on Industrial Radiography : Mr. N. Clarke, Mr. F. Y. Poynton and Mr. W. E. Schall.

On the Joint Committee with the Ministry of Education for National Certificates in Applied Physics : Dr. J. S. Forrest, Mr. A. E. De Barr, Mr. A. T. Pickles and Dr. J. Topping.

On the Joint Committee with the Scottish Education Department for National Certificates in Applied Physics : Mr. T. H. O'Beirne, Dr. J. M. A. Lenihan, and Dr. R. S. Silver.

On the British Committee for Radiological Units : Mr. W. Binks.

On the Joint Committee (with The American Society for Testing Materials and The American Crystallographic Association) for Chemical Analysis by X-ray Diffraction Methods : Prof. A. J. C. Wilson.

On the Physics and Mathematics Advisory Panel of the Technical and Scientific Register of the Ministry of Labour : The President and Dr. H. R. Lang.

On the Panel of the Ministry of Labour and National Service dealing with Industrial Use of Ionizing Radiations : Mr. H. P. Rooksby, Mr. W. E. Schall.

On the London Regional Advisory Committee on Applied Physics : Mr. N. Clarke, Mr. F. Y. Poynton and Mr. G. W. Warren.

On the Court of Governors of the Manchester College of Science and Technology : Sir John Cockcroft.

On the Court of the University of Hull : Dr. E. C. Craven.

On the Court of the University of Exeter : Prof. S. H. Piper.

On the Regional Council for Further Education for the South West : Prof. S. H. Piper.

On the Governing Body of Croydon Technical College : Mr. C. L. S. Gilford.

On the Governing Body of Norwood Technical College : Dr. A. J. Maddock.

On the Advisory Sub-Committee for Electrical Engineering and Applied Physics of Cardiff College of Technology and Commerce : Mr. R. G. Wood.

On the Sub-Committee on Specialist Courses in Electrical Engineering of the Welsh Academic Board of Technology : Mr. W. S. Vernon.

On the Consultative Committee for Electrical Engineering and Applied Physics of the South East London Technical College : Dr. C. G. Wynne.

On the Applied Science Advisory Committee of the Royal Technical College, Salford : Mr. D. A. Crooks.

On the Science Advisory Committee of the Ipswich School of Technology : Mr. H. A. Nancarrow.

On the Science Advisory Committee of Blackburn Technical College : Dr. R. Schnurmann.

On the Science Advisory Committee of Bury Municipal Technical College : Mr. H. Potter.

On the Science Advisory Committee of Croydon Technical College : Mr. S. Hill.

On the Applied Science Advisory Committee of the Wolverhampton and Staffordshire College of Technology : Dr. D. E. C. Corbridge.

On the Science Advisory Committee of Luton and South Bedfordshire College of Further Education : Dr. R. W. Williams.

On the Science Advisory Sub-Committee of Poole College for Further Education : Mr. C. F. Oxbrow.

On the Advisory Committee for Applied Physics of Kingston Technical College : Dr. G. D. Robinson.

On the Advisory Committee for Physics of West Ham College of Technology : Mr. L. V. Chilton.

On the Science Advisory Committee of Northampton College of Technology : Dr. J. T. Kendall.

On the Science Sub-Committee of the Eastern Area Technological Committee of the East Anglian Regional Advisory Council for Further Education : Mr. H. A. Nancarrow.

On the Yorkshire Council for Further Education Advisory Panel for Applied Physics : Mr. S. L. Anderson, Dr. K. W. Andrews, Dr. M. O. Pelton and Mr. E. Wilfred Taylor.

On the Buckinghamshire County Education Committee, Slough Area Science Advisory Committee : Mr. J. Yarwood.

On the Congress Council of the Third International Congress on High Speed Photography : Dr. B. P. Dudding.

On British Standards Institution Committees : The Institute has been represented on twenty-five Committees of the B.S.I.

General Meeting

The 26th Annual General Meeting of the Institute was held on July 16 in the Institute's House.

Election of Honorary Fellow

At the meeting on July 16 Sir George Thomson was declared elected an Honorary Fellow.

Membership

During the year 752 applications for election or transfer to the various grades were received for submission to the Membership and Examinations Committee, compared with 726 applications in 1956. The numbers for the grades (with the 1956 numbers in brackets) were : Fellows 64 (62), Associates 297 (213), Graduates 238 (244), Students 128 (171), Subscribers 25 (36). The Interview Panel met three times and interviewed eleven candidates. Representatives of the Committee visited four technical colleges which had applied for recognition by the Institute.

The Committee, which is now charged by the Board with the responsibility of giving advice on educational matters, has set up two panels, one to consider the revision of the lists of recognized qualifications and the other to submit a report on suggested means of stimulating entry to the profession.

The continued growth of the Institute is shown in the following table.

Table 1

Growth of the Institute over the last ten years

1947	...	3268	1952	...	4347
1948	...	3455	1953	...	4595
1949	...	3657	1954	...	4749
1950	...	3858	1955	...	5146
1951	...	4080	1956	...	5531

The changes that have occurred during the year are displayed in Table 2.

Deaths. The Board records with regret the deaths in 1956 of :

Fellows : J. J. Durack, W. G. Kannuluik, C. Kershaw, C. Liebmann, P. C. Mahanti, A. O. Rankine, H. R. Robinson, S. G. Starling, Sir Francis Simon, E. B. Wedmore, S. Whitehead. *Associates :* S. E. Ashmore, C. B. Childs, A. M. Davies, C. E. Eddy, C. P. Falls, N. A. Faull, S. Geddes, J. C. Hickman, J. M. Macauley, F. P. Sexton, F. F. P. Walsh. *Graduates :* H. A. Adams, A. H. Boud, P. A. Kenyon. *Subscribers :* L. H. Bainbridge-Bell, P. Bilham.

Although tributes to Professor A. O. Rankine and Dr. S. Whitehead were published in the *Bulletin* during the year, the Board wishes to record here again its sense of personal loss in the passing of these two Fellows who devoted so much of their time and energy to the Institute's affairs. Professor Rankine was Honorary Secretary from 1926-32 and a Vice-President from 1933-37. Dr. Whitehead had been Chairman of the

Table 2. *Changes in the Register in 1956*

	Total on Dec. 31, 1955	*Elections*		*Re-admitted*	*Resigned*	*Deceased*	*Removed*	*Transfers from*	*Net Increase or Decrease*	*Total on Dec. 31, 1956*
		New	*Transfers to*							
Hon. Fellows	6	—	1	—	—	—	—	—	+ 1	7
Fellows ...	1012	8	38	1	4	11	1	1	+ 30	1042
Associates ...	2008	155	111	1	14	11	1	38	+203	2211
Graduates ...	1091	167	66	—	8	3	4	114	+104	1195
Subscribers...	461	30	4	—	20	2	2	1	+ 9	470
Students ...	568	150	—	—	14	—	32	66	+ 38	606
TOTAL ...	5146	510	220	2	60	27	40	220	+385	5531

London and Home Counties Branch and a Vice-President of the Institute, becoming its Honorary Treasurer in 1951—an office he held at the time of his death.

Group Subscribership

For some time discussions have been going on about the conditions under which non-physicists can become members of the single Group in which they are interested. During the year, the Board accepted for a trial period of two years a recommendation that there should be a grade called "Group Subscriber." The annual fee will be one guinea a year. Group Subscribers may not regard themselves as members of the Institute, nor are they entitled to the Institute's publications. Their privileges are limited to participation in a single Group's activities. If there appears to be any general demand for this grade, the position will be regularized at the end of the trial period.

Examinations

Graduateship Examination. The Graduateship Examination was held on June 11–15. Written papers were taken at the Institute's House, the College of Technology, Birmingham, Paisley Technical College and the Royal Technical College, Salford. The practical examination was held at the Polytechnic, Regent Street, London. The papers were published in the September *Bulletin* with the comments of the Examiners and were subsequently published in pamphlet form.

The examination was taken by 45 candidates (there were 54 in 1955) and seven satisfied the examiners (compared with 11 in 1955). Fourteen question papers were set. The examiners were : Professor J. G. Wilson, Dr. J. Topping, Mr. A. E. De Barr, Mr. J. Yarwood, Mr. E. D. van Rest, Professor H. Lipson and Mr. N. Clarke.

National Certificates in Applied Physics. The number of students taking the final examinations for Ordinary and Higher National Certificates in Applied Physics continues to increase most satisfactorily. In 1956 424 students took the Ordinary certificate examination (compared with 309 in 1955) and 152 took the Higher certificate examination (82 in 1955). The Institute's assessors were Dr. J. Topping, Mr. G. W. Warren and Professor J. D. Craggs for England and Wales and Dr. G. Morris for Scotland.

Honorary Representatives

In order to provide a link between the Institute on the one hand and universities and recognized colleges on the other the Board has invited a number of Fellows and Associates to act as its honorary representatives in these institutions. Students and others who wish to have information about membership regulations, examination requirements or Institute publications may inquire of the appropriate representative for relevant forms or published information. The list of members who have so far accepted the Board's invitation to act in this way was published in the January, 1957, *Bulletin.*

Education

Higher Technological Education. The Board welcomed the publication by the Government of the White Paper on Technical Education (Cmd 9703). Many of the proposals contained in the White Paper are along the lines of advance that have been advocated by the Institute since the publication of its report on the Education and Training of Technologists in 1948.

Training of Technical Teachers. The Institute was among the bodies invited by the Ministry of Education to submit views for the consideration of a Committee set up by the Ministry to give advice on the supply and training of technical teachers. A reply was sent on behalf of the Board. It expressed the Board's appreciation of the setting up of the Committee and made some recommendations ; it also stressed the view that any increase in the supply of technical teachers should avoid decreasing the number of teachers in universities and schools and the number of scientists engaged in other important work.

Recognition of Colleges. Representatives of the Institute visited those technical colleges which had applied for recognition or a continuation of recognition, and this was granted to the following during the year under review.

The Technical College, Swansea ;
The Medway College of Technology ;
Bolton Technical College ;
Reading Technical College ;
Southend Municipal College ;
Ewell Technical College.

Recognition in this way does not involve the acceptance of diplomas awarded by any of these colleges, but is concerned only with satisfactory evidence of compliance with the membership regulations regarding the adequacy of training in physics.

Recognition of College Diplomas. The Board agreed to accept one further technical college diploma in physics—that of the Northern Polytechnic, London—as giving complete exemption from the Institute's academic requirements for Graduateship. In the previous year five such diplomas had been accepted, three of which were to be awarded on satisfactory completion of "sandwich courses." This is an expression of the Board's policy that the major technical colleges should be encouraged to develop towards academic and financial autonomy.

Degree and Diploma Courses in Applied Physics. In co-operation with the London and Home Counties Regional Advisory Council for Higher Technological Education the Board arranged a conference on "Degree and Diploma Courses in Applied Physics" which is referred to elsewhere in this Report.

Publications

The Journals. The increase in circulation of both Journals to libraries and non-members was about double what it has been for the last few years ; it was 402 for the *Journal of Scientific Instruments* and 297 for the *British Journal of Applied Physics.* The effect on the circulation of requiring members to pay for their copies, was less than anticipated ; almost exactly half of those who took each Journal in 1955 took them in 1956.

The revenue from the advertisements showed a satisfactory increase. This is now one of the principal sources of the Institute's income, and the Board is grateful to those members who have encouraged the support of our advertisement columns.

Table 3 shows the amount of material submitted and published during the year, compared with the previous year's figures. Of the 156 papers submitted to the *Journal of Scientific Instruments* during the year and the 119 to the *British Journal of Applied Physics,* 44 and 29 respectively were still under consideration at the end of the year. The Board welcomes this opportunity of thanking those Fellows and others who have refereed papers

Table 3. *Contributions submitted and published*

	J.S.I.		*B.J.A.P.*	
	1955	1956	*1955*	1956
Extent of Journal (*text pages*)	*496*	512	*454*	456
Original papers (*numbers*) :				
Submitted	*144*	156	*122*	119
Accepted	*111*	96	*88*	60
Published	*117*	117	*97*	74
Special articles and conference reports published (*numbers*)	*5*	4	*7*	14
Laboratory and Workshop Notes (*numbers*) :				
Submitted	*93*	96	—	—
Accepted	*68*	64	—	—
Published	*64*	75	—	—
New Instruments, Materials and Tools :				
Items published	*43*	82	—	—
Notices for manufacturers' publications	*12*	53	—	—
Letters to the Editor published	*27*	24	*14*	21
Number of book reviews published	*23*	13	*88*	111
Extent of Supplement (*text pages*)	—	—	*111*	107

or reviewed books or assisted the Editor in other ways. It is to them that the maintenance of the high standard of the *Journals* is largely due.

The " average delay " between first receipt of script and publication remained around six months for both Journals, but the actual delay varied between three and ten months depending largely on factors beyond the Editor's control.

The fifth Supplement to the *British Journal of Applied Physics* was published in November and contained the proceedings of the conference on " The physics of nuclear reactors " held in July.

Bulletin. As a development of the publication policy of the Institute, the *Bulletin* was this year further expanded and published in an entirely new format. It is the only periodical of the Institute to which all members are entitled without extra payment and its development was intended to permit the wide publication of articles of general interest, which had been specially invited or based upon lectures presented to the Branches and Groups, and at the same time to continue the publication of information of professional interest. From a large number of comments made it is clear that the new *Bulletin* has been widely welcomed and has met a need.

The twelve monthly-issues consisted of 344 + xcvi pages. Twenty-three articles were published, together with news of Branch and Group activities, lists of new elections and summaries of the principal contents of the Institute's two scientific journals. Reviews of thirty-six books were published and a total of 439 advertisements for physicists or technicians were included (compared with 403 in 1955 and 214 in 1954).

Science Abstracts. The agreement with the Management Committee of *Science Abstracts* concerning the special terms upon which members of the Institute may contribute to this periodical was renewed for a further three years from its expiry at the end of 1956. The Board requested its representatives on the Management Committee to put its views concerning the abstracting of conference proceedings and of papers on nuclear physics and nuclear power before the Committee.

Conferences and Symposia

Branch and Group Conferences. The several conferences and symposia arranged by individual Branches or Groups are mentioned in that section of this Report.

Conference on " The physics of nuclear reactors." The purpose of the conference on " The physics of nuclear reactors," which was held in London from July 3–6, was to keep members of the Institute and its sister Institutions abreast of scientific developments in nuclear reactors and to call their attention to the problems needing solution. It was attended by nearly 500 persons from twenty-five different countries. A brief account of the conference will be found in the *Bulletin* for August, 1956, and (with one exception) the lectures and papers given at the conference, and the discussion on them were published in November as Supplement No. 5 to the *British Journal of Applied Physics.* The Board records here its thanks to the staff of the Atomic Energy Authority for their help and support in many ways, which did so much to make this conference one of the most successful the Institute has held.

Conference on Degree and Diploma Courses in Applied Physics. This conference was arranged jointly by the Institute and the London and Home Counties Regional Advisory Council for Higher Technological Education and was held in The Institution of Electrical Engineers' building on November 15 and 16. There were about 160 people present, more than half of them being senior representatives of industry or Government service. The proceedings of the conference, including the discussion, are being published in the *Bulletin* and as a separate pamphlet for general sale.

Meetings on physics of nuclear power. Following the July conference on " The physics of nuclear reactors " inquiries were received about future meetings on this and cognate subjects. The Board, therefore, appointed a small Committee on which The Physical Society was represented " to make recommendations for meetings (once or twice a year) on the physics of nuclear power to be held in collaboration with The British Nuclear Energy Conference, of which the Institute is a constituent body." The Committee's report was approved in December, and it is hoped to make arrangements for both survey papers and for the reading and discussion of specialist papers, as and when required.

Professional Matters

Inquiries. The number and nature of the inquiries concerning professional matters were much the same as in previous years ; they concerned contracts of service, requests for consultants, availability of courses, salary inquiries, conditions of employment, overseas prospects, liability for increased life insurance premiums on account of possible radiation hazards, liability for National Service, and so on. These were dealt with by the Permanent Officers, often advised by the Honorary Officers or other Fellows of the Institute with special knowledge or experience.

Salary Survey. The Board authorized a fourth survey of salaries and emoluments of Fellows, Associates and Graduates and this was made in October. There was a good response and the Board is grateful to all members who supplied information. A report on the survey was published in the *Bulletin* of January, 1957.

Inquiry into the occupation of graduates. The Board received a report on the annual inquiry regarding the kind of post taken up by those who had graduated in physics in 1955, which had been extended on this occasion to those receiving Ph.D. and M.Sc. degrees. A similar inquiry is being made in respect of 1956 graduates, and this will be continued for another year or two. The Board expresses its thanks to the Heads of Departments who have made these inquiries possible. In considering the last report the Board decided that it would be useful to have a fuller one prepared for its own use and covering the first three inquiries. Later this report may be published with comments in the *Bulletin.*

Demand for physicists. The Board was invited by the Scientific Manpower Committee of the Government's Advisory Council on Scientific Policy to give an estimate of the likely demand for physicists in about ten years' time. It replied as follows : " The Board has no good statistical information on which to estimate the increase in the demand for physicists over the next ten years. There is a general agreement, however, among members of the Board that if the number of graduates in physics could be doubled within five to ten years the demand could still exceed the supply." A report based on such inquiries was later published jointly by the Ministry of Labour and National Service and the Office of the Lord President of the Council. It recommended a doubling of the numbers of qualified scientists by 1970.

The Institute's House

New lease. As reported last year, agreement in principle was reached between the Institute, the Grosvenor Estate (the ground landlords) and the Estate of Lord Mount Edgcumbe (the Institute's Landlord) for a new lease. During the year the detailed negotiations were continued.

Rates. The Institute's application for some relief from the rates was unsuccessful, but a new application may be made when the present complex legal position is clarified.

Repairs and decorations. The main staircase and the members' room were redecorated during the year, and a few essential repairs carried out.

Gifts. The Board records with gratitude the gift of a 16mm sound-film projector by the Research Laboratory of The British Thomson-Houston Co. Ltd. as " an appreciation of the work of the Institute and particularly its value to industry."

The Board's thanks are also due to the late Dr. S. Whitehead and his wife, for the tapestry firescreen for the Board room, in which they have skilfully worked the Institute's badge.

Meetings. The number of meetings held in the House during the year is shown in Table 4.

Table 4. *Meetings held in the House*

Institute meetings	*1955*	1956
Board and Committee meetings (including Branch and Group Committees) -	*76*	59
Conference and Lecture meetings - - -	*45*	30
Social functions - -	*6*	5

Other meetings	*1955*	1956
The rooms have also been used by other bodies as follows :		
Committee meetings -	*17*	11
Lecture meetings -	*8*	9

The American Institute of Physics

A cable of congratulations was sent to The American Institute of Physics on the occasion of its Silver Jubilee. The close and cordial relations that have existed since its foundation have proved of direct value to the members of both bodies.

Acknowledgments

Branch, Group and Conference Officers. The Board wishes to record its thanks to those members who have acted as Honorary Officers of the Institute's Branches, Groups and Conferences and who have thereby contributed greatly to the Institute's activities.

Meeting Rooms and Visits. The Board records its thanks to the many bodies which have generously allowed meetings of the Institute and of its Branches and Groups to be held on their premises or which have allowed visits to their laboratories.

Finance

The accounts are presented in the usual form with the same proportional allocation between them of the costs of running the House and the offices, as has been used since 1952. The final surplus for the year on the combined accounts (Institute and Endowment Trust Fund) is £1,330.

The Institute of Physics Accounts. The new arrangements regarding the distribution of publications are reflected in this account. Some £2,000 has been saved on the copies of Journals previously distributed to members without extra charge, but on the other hand, the improved *Bulletin* has cost substantially more than last year. There is a welcome increase in the income from members' subscriptions. Following the normal practice, funds have been transferred from this account to the Endowment Trust Fund Account, so that members' subscriptions contribute towards the cost of educational and scientific work borne by the Trust Fund. The amount for the year was £3,500.

Endowment Trust Fund Accounts. The publications business, which now forms the major part of these accounts, showed a satisfactory surplus. In accordance with the Board's policy the stock of publications has been further depreciated, but the reserve for depreciation of the stock of books has been kept at £2,000.

Negotiations for establishing the X-ray Index Fund as a separate Trust are proceeding. The use to which this money can be put is limited by the arrangements between the Institute and The American Society for Testing Materials, who are the publishers of the card index file from which it is derived.

Benevolent Fund

Subscriptions and donations from members amounted to £644 compared with £536 the previous year. The Fund Committee is grateful to them for this help and to those who have provided the royalties from books.

The Trust established under the will of the late Mrs. W. Phillips paid £608 to the Fund in 1956. These figures include the refund of income tax paid.

The calls on the Fund have, fortunately, been small (five old cases and four new ones), so that a further £891 has been added to the capital account, which now stands at a little over £6,000. The Committee wishes to build up a substantial Fund in order to be able to give adequate help to more members and their dependents, should circumstances supervene that might make that desirable.

The Fund Committee has expressed to the Board its appreciation of the help and guidance it has received from members who have investigated cases on its behalf and acted as Trustees of Funds provided.

Branches and Groups

Annual meeting of Branch and Group Officers. The thirteenth annual consultative meeting of the Honorary Officers of Branches and Groups was held in the Institute's House on July 16. The meeting considered a report from the Secretary in which he enlarged on items referred to only briefly in published reports. A discussion on ways and means of stimulating entry to the profession produced some suggestions which are being looked into by the Board. Other items considered were the *Bulletin*, and the method of charging for attendance and accommodation at Group and Branch conferences.

Proposed New Groups. During the year the Board considered an inquiry about the possibility of forming a " nuclear magnetic resonance " Group. Arising from this, the Liverpool and North Wales Branch, at the request of the Board, held a symposium in Bangor on this subject on September 26 and 27, during which a business meeting was held to consider the proposal ; The Physical Society was officially represented at this meeting. It was decided to form a " Radiofrequency Spectroscopy " Group, to cover " all branches of spectroscopy up to about 10^{11} c/s," and to invite the Board to consult with the Council of The Physical Society about the sponsorship of the proposed Group.

The representatives of The Physical Society reported to the Board on approaches to their Council for the formation of a nuclear physics group. As mentioned above, following the July Conference on " The physics of nuclear reactors " inquiries were received about the possible formation of a Group devoted to this and cognate subjects.

In view of these developments the Board has begun a re-examination of the terms of membership and operation of the Groups with a view particularly of seeing how best the Institute and The Physical Society can between them provide adequate opportunities for the reading of original papers and for discussion of the several new and old branches of pure and applied physics.

Australian Branch. *President :* Dr. F. W. G. White. *Vice-President :* Prof. H. C. Webster. *Honorary Secretary :* Mr. K. C. Lang. *Honorary Treasurer :* Dr. J. S. Rogers. (419 members.)

The Divisions of the Branch in the different states have again held many meetings.

A conference on " Contemporary Optics " was held under the auspices of the New South Wales Division in Sydney on September 19–21 ; all major optics laboratories within the Commonwealth and five of the six States were represented at the meetings.

The Institute was represented by the President of the Branch at a conference called by the Australian Academy of Science to discuss means of alleviating the present shortage of scientific and technological manpower.

The Branch is represented as follows :

National Committee of Pure and Applied Physics (*Australian Academy of Science*) *:* The Branch Committee.

Australian National Committee on Illumination : Mr. R. Blevin.

National Association of Testing Authorities : Dr. N. B. Lewis.

Australian Journal of Physics Editorial Committee : Dr. G. H. Briggs.

Australian National Committee of UNESCO for the Natural Sciences : Dr. G. H. Briggs.

Malayan Branch. The inaugural meeting of the Malayan Branch was held in Singapore on May 9. Mr. C. G. Webb was elected Chairman and Dr. Thong Saw Pak, Honorary Secretary. A display of instruments and the showing of a film concerning radioactivity formed part of this first meeting.

Liverpool and North Wales Branch. *Chairman :* Professor E. A. Owen. *Honorary Secretary :* Professor J. D. Craggs. (197 members.)

Six lectures were held in Liverpool. Two lectures and a two-day symposium on " Nuclear magnetic resonance " (*see above*) were held in Bangor.

London and Home Counties Branch. *Chairman :* Dr. J. S. Forrest. *Honorary Secretary :* Mr. B. S. Cooper, succeeded by Mr. D. T. R. Dighton. (2,315 members.)

Six lectures were held in London. A joint symposium with the corresponding branches of The Royal Institute of Chemistry and The Institute of Biology on " The presentation of science to the public " was held in the Senate House of the University of London. There were visits to The National Institute for Medical Research and the Research Laboratory of Associated Electrical Industries Ltd. at Aldermaston. For the summer meeting a visit was arranged to the Houses of Parliament and from there the party went by river to the Royal Naval

College and the National Maritime Museum at Greenwich.

Manchester and District Branch. *Chairman :* Dr. R. W. Sillars. *Honorary Secretary :* Dr. D. G. Drummond. (351 members.)

Six lectures were held in Manchester as well as a joint discussion with the Education Group on " The ethical problems confronting a young scientist in the atomic age." A summer visit was arranged to the Imperial Chemical Industries Ltd.'s Rock Salt Mine at Winsford. The Branch annual dinner was held in March.

Midland Branch. *Chairman :* Professor P. B. Moon. *Honorary Secretary :* Dr. R. J. Wakelin. (544 members.)

Six lectures were held in Birmingham. A visit to Taylor, Taylor and Hobson Ltd. in Leicester was followed by a paper on " Fine measurements." In December a party visited the British Railways Research Department and heard talks on " The Hall Effect " and " The Application of Physics to British Railways." The Branch annual dinner was held in March.

North Eastern Branch. *Chairman :* Professor W. E. Curtis. *Honorary Secretary :* Dr. N. Thorley, succeeded by Mr. J. E. Caffyn. (136 members.)

Three lectures were held in Newcastle and two in Durham.

Scottish Branch. *Chairman :* Dr. J. M. A. Lenihan. *Honorary Secretary :* Mr. T. H. O'Beirne, succeeded by Dr. A. R. Boyle. (280 members.)

Four lectures were held in Edinburgh, one in Aberdeen and one in Dundee. Nine lectures were held in Glasgow, five of them forming part of a series on " New materials."

South Wales Branch. *Chairman :* Mr. R. G. Wood, succeeded by Professor R. M. Davies. *Honorary Secretary :* Dr. M. R. Hopkins. (286 members.)

Three lectures were held in Cardiff, two in Swansea and one in Aberystwyth. A one-day conference on " Physics in industry " was held in Cardiff, during which Sir John Cockcroft gave a public address on " The future of science and technology in industry " which was published in the June issue of the *Bulletin.*

South-Western Branch. At its December meeting the Board agreed, in principle, to the formation of a Branch based on Bristol, in response to a formal request and signed by eight local members.

Yorkshire Branch. *Chairman :* Professor W. Sucksmith. *Honorary Secretary :* Dr. R. S. Tebble. (246 members.)

Three lectures were held in Leeds and one in Sheffield. A visit was paid to Imperial Chemical Industries Ltd. at Harrogate.

Education Group. *Chairman :* Dr. J. Topping, succeeded by Mr. G. W. Warren. *Honorary Secretary :* Mr. F. Y. Poynton, succeeded by Mr. T. H. Tyler. (284 members.)

Four lectures were held in London, as were a discussion on " The availability of places for physics students in universities and technical colleges " and the Group two-day annual conference. A joint discussion with the Manchester and District Branch is recorded above. The summer visit was to Eton College.

Electronics Group. *Chairman :* Mr. M. E. Haine. *Honorary Secretary :* Mr. S. Rodda. (369 members.)

Seven lectures were held in London. A visit was paid to the Services Electronics Research Laboratory at Baldock. A symposium on thin films was held in Reading. Two colloquia were held jointly with The Physical Society.

Electron Microscopy Group. *Chairman :* Dr. D. G. Drummond. *Honorary Secretary :* Dr. C. E. Challice. (269 members.)

A conference on textile and other industrial fibres was held in the University of Leeds and the annual Group conference in the University of Reading.

Industrial Spectroscopy Group. *Chairman :* Mr. D. M. Smith, succeeded by Dr. A. C. G. Menzies. *Honorary Secretary :* Mr. J. R. Stansfield, succeeded by Mr. F. W. J. Garton. (166 members.)

Three lectures were held in London. The summer meeting and the Group annual dinner took place in Swansea.

Non-Destructive Testing Group. *Chairman :* Dr. J. Thewlis. *Honorary Secretary :* Mr. R. S. Sharpe. (349 members.)

Six lectures and a symposium were held in London. A visit was made to Guy's Hospital Medical School. The Group summer meeting on " The physics of some new aspects of non-destructive testing " was held in Bristol ; the contributions to this symposium are being published as a supplement to the *British Journal of Applied Physics.*

Stress Analysis Group. *Chairman :* Mr. E. K. Frankl. *Honorary Secretary :* Mr. B. Sugarman. (162 members.)

A meeting was held at the Royal Aircraft Establishment, Farnborough. Visits were made to the Dunlop Research Laboratories at Birmingham and the Admiralty Laboratory at West Drayton. A two-day joint conference with The Royal Aeronautical Society was held at Cranfield in September.

X-ray Analysis Group. *Chairman :* Mr. H. P. Rooksby, succeeded by Professor E. G. Cox. *Honorary Secretary :* Dr. U. W. Arndt. (447 members.)

A joint conference with the Low Temperature Group of The Physical Society on low temperature crystallography was held at Oxford. The autumn conference on biological structures and computational methods was held in London.

The Group's Equipment Sub-Committee has continued its work on matters affecting apparatus and materials used in X-ray crystallography. Work is in progress under the auspices of the Group on the collection of crystallographic data. Single crystal information obtained from published literature is being prepared for a new Single Crystal Index at the University of Leeds and at the National Institute for Medical Research, Mill Hill ; and at University College, Cardiff, the preparation of contributions to the A.S.T.M. Powder Data File has continued.

Extracts from Reports to the Board of Representatives and Nominees on Joint Committees and other Bodies

Parliamentary and Scientific Committee. During the year the Committee discussed a number of matters which were before Parliament and were of special interest to scientists and their organizations. Among these were higher technological education and scientific manpower, the copyright bill, the D.S.I.R. bill and the liability of scientific organizations to local rates.

The Committee held eight meetings during the year and amongst the subjects on which it was addressed were the following : Training and utilization of scientists and technologists in the Soviet Union ; the development of Britain's physical and geographical advantages ; and factors in evolving a new scientific policy for the better exploitation of Great Britain's main natural advantages. In February the Prime Minister was the Guest of Honour at the annual luncheon and spoke about the Government's policy on higher technological education, and in March the Minister of Education addressed the Committee on this subject. In June the Committee was addressed by the Lord President of the Council on the Government's policy regarding the development of atomic energy. His address was followed by a short discussion.

The Secretary was appointed a member of the Steering Committee.

Committee of Management of " Science Abstracts." The Committee has held two meetings during the past year. Reports on the new method of pro-printing were received. The question of coverage for the rapidly increasing number of publications continued to engage its attention.

The Royal Society's Paul Instrument Fund Committee. The Committee met once during 1956 but transacted a considerable amount of business by correspondence. For projects previously authorized, grants of over £3,000 were paid and grants for new researches or extension of previous work were authorized amounting to nearly £7,000. The year marked the virtual completion of the project at Bristol, initiated by Professor N. F. Mott and carried on after 1954 by Professor M. H. L. Pryce, for the construction of a meteor camera which will be used at Jodrell Bank by Professor A. C. B. Lovell. Tribute must be paid to those who contributed both ideas and great constructional skill to the project for which grants totalling over £20,000 were made from the Paul Instrument Fund.

The Royal Society's National Committee for Crystallography. The Committee met twice during 1956. The most important matters discussed were arrangements in connection with the 4th General Assembly and International Congress to be held in Montreal in July, 1957, and the proposal to hold the 5th General Assembly in Cambridge in 1960.

The Royal Society's National Committee for Physics. The Committee has not met during the period, but the secretariat has continued to circulate information on conferences, etc., held under the auspices of the International Union of Pure and Applied Physics to which it adheres.

National Council for Technological Awards : Board of Studies in Technologies other than Engineering. The National Council has now an independent existence : its Trust deed was signed on November 22, 1956. Dr. Topping, who has taken a leading part in the Institute's educational work, has been elected Vice-Chairman of the Board and also a member of the National Council itself. The Council has issued a Memorandum on the recognition of courses in Technical Colleges leading to the Diploma in Technology, and a number of applications for recognition have been received and examined. Recognition, when granted, will normally be for a period of five years. A physics panel has been appointed to report upon the suitability of facilities and courses for recognition.

Joint Committee (with The American Society for Testing Materials and The American Crystallographic Association) on Chemical Analysis by Powder X-ray Diffraction Methods. The collection of corrections to the earlier data cards, issued by The American Society for Testing Materials, mentioned in the 1955 Report, was circulated in March, 1956. A further set of " Comments " was prepared, and was sent out by our Institute in December, 1956. It is proposed to continue the issue of these " Comments " at approximately yearly intervals.

The seventh set of data cards will be issued during 1957.

Board of the British Nuclear Energy Conference. During the year the Board met four times. Apart from regular business including items concerned with the production of its journal, the discussions on the constitution of the Board and the admission of other bodies were continued and satisfactorily concluded at the end of the year. The principal activity was the symposium on Calder Hall held on November 22–23, which was attended by nearly 2,000 people.

The whole of the Proceedings of the Institute's conference on " The physics of nuclear reactors " was republished in this body's journal.

Physics and Mathematics Advisory Committee of the Ministry of Labour and National Service. The Minister has approved the proposal originally made by the Institute's representatives that this Advisory Committee be converted into an Advisory Panel, the individual members of which could be consulted as and when required.

Ministry of Labour and National Service's Panel on Special Regulations for Protection against Ionizing Radiations. The aim of the Panel is to draft regulations that will control the use of all kinds of ionizing radiations in factories and other establishments covered by the Factories Act, 1937. To simplify procedure the Panel decided to separate the regulations into two parts, one dealing with closed sources and the other with open sources. The main effort has been concentrated on part one, so that at least a substantial part of the problem could be completed quickly. Between March and the end of the year, eleven meetings were held. Progress was considerable, and the work on part one was almost completed at the end of the year.

London and Home Counties Regional Advisory Committee in Applied Physics. The Committee has continued to be active and has advised on the location of physics courses proposed by colleges in the area. It was at the suggestion of the Committee that the successful conference on Degree and Diploma Courses in Applied Physics was held in November (referred to on p. 119 of this report).

Regional Council for Further Education for the South-West. The Council has continued its work towards ensuring that adequate courses are available in the region in the various technical subjects.

The Governing Body of Croydon Technical College. Among matters considered by the Governors during the year was the further development of the College technical library to meet present and future needs. An advanced course in Electronic Engineering has been started and a new course in Industrial Electronics is proposed.

The City and Guilds of London Institute, Advisory Committee on Industrial Radiography. The syllabus for the examination of Industrial Radiographers having been drawn up and approved at the end of 1955, an examination was set to take place in May, 1956. There was, however, only one candidate, and the examination was not held.

A meeting of the Committee took place in December, 1956, when it was decided on the request of the Principal of one Technical College that the physics curriculum should be re-examined and perhaps divided into " intermediate " and " final " stages. A sub-committee is to examine the proposal.

Advisory Committee for Science of the Luton and South Bedfordshire College of Further Education. The Committee met three times. The principal topics with which the Committee has concerned itself are the provision of sandwich courses, the choice of books for the new science library, and progress reports on the new buildings.

Science Advisory Sub-Committee of the Poole College for Further Education. Two meetings were held to consider staffing and estimates for equipping the new buildings of the Technical College which were brought into use in September, 1956. Instruction in physics is to be provided only up to the level required for corporate members of the Engineering Institutions. The facilities available in the adjoining County Borough of Bournemouth will be relied upon for instruction in physics to more advanced levels.

Advisory Sub-Committee for Electrical Engineering and Applied Physics of Cardiff College of Technology and Commerce. This Committee met once during 1956. A report by the Head of the Department of Applied Physics and Electrical Engineering pointed out that the present period is one of transition. Full-time degree work has disappeared, whilst at the same time elementary work is being discarded. Nevertheless the number of students shows little change. New courses, accommodation, equipment and research projects were reported, indicating an active and growing department.

Science Advisory Committee of Northampton College of Technology. The inaugural meeting of this Committee was held in December, at which a report covering the work of the Science Department during the session 1955/56 was approved for submission to the Governors of the College. The Committee urgently recommended increases in accommodation, equipment and staff. In the spring of 1956 a questionnaire was circulated to firms concerning the possibility of introducing a National Certificate course in physics leading to the Higher National Certificate with emphasis on electronics ; the response did not, however, warrant the introduction of such a course at present.

Advisory Committee in Applied Science of Wolverhampton and Staffordshire College of Technology. Discussions have been held on sandwich courses, metallurgical laboratory facilities, new courses, and postgraduate activities which continue to expand. Two new postgraduate sections concerned with X-ray diffraction and spectrochemistry, have been inaugurated in the department.

Science Advisory Committee of the Governing Body for Technical and Further Education, Slough Area. The Committee met once and among other matters considered the arrangements for courses in applied physics leading to National Certificates. Efforts have been made in the College to increase and improve facilities for research.

BRITISH STANDARDS INSTITUTION COMMITTEES

Committees on Units and Symbols Standards. New standards prepared by Sub-Committees which are nearly completed, or are with the printer, are (1) the reduction and presentation of experimental results ; (2) precise conversion of inch and metric sizes on engineering drawings ; (3) glossary of terms in use for high vacuum technology. Reports from representatives on other Sub-Committees appear below.

A substantial revision of B.S.350, Conversion factors and tables, is being made. It is planned to issue the revised standard in two parts and it is hoped to publish part one, dealing with units and interconversion factors, in 1957. Part two, Detailed conversion tables, will follow.

Sub-Committee on Glossary of Terms used in Nuclear Sciences. The Committee met monthly throughout the year and continued with the task of defining terms used in nuclear science. A preliminary report containing a list of all the terms to be defined, as well as definitions already approved, has been printed and circulated to a large number of institutions for comment.

Technical Committee for Co-ordination of Definitions, Units and Technical Data. The Committee and its Sub-Committees have continued their work on the preparation of new parts of B.S.1991, *Letter Symbols, Signs and Abbreviations, Part I General* of which was published in 1954.

The Committee, in co-operation with other B.S.I. Committees, has also considered a number of international draft standards for symbols, signs and abbreviations.

The new parts will cover chemical engineering and applied chemistry, fluid mechanics, strength of materials and structures and heat engines.

Sub-Committee on Terms in Use for High Vacuum Technology. This Sub-Committee held several meetings and finished its difficult task of preparing a first draft of the Glossary.

Technical Committee on Glossary of Rubber Terms. The Committee has met six times and found that those terms which have more general meanings have occasioned a fair amount of discussion.

Instrument Industry Standards Committee. At its annual meeting the Committee reviewed the work of its several Sub-Committees and considered proposals for the new work. It also had before it a statement by the B.S.I. Export Panel, in which it was asked to make suggestions as to the manner in which the recommendations might be implemented in the instrument industry.

Technical Committee on Radiology. The Committee met once and considered drafts of a Memorandum on Therapeutic X-ray equipment, and of a standard for gamma-ray source capsules, for submission to the Electrical Industry Standards Committee. A Sub-Committee to consider the preparation of a standard for film monitoring was appointed.

Sub-Committee on Radiation Monitoring Techniques and Film Holders. This Committee met twice ; it concluded that the time for standardization of films and film holders for monitoring purposes is not yet ripe. It is believed that standardization might hamper progress in a field in which the methods are not sufficiently established. An attempt to standardize might be reconsidered after one or two years.

Sub-Committee on Barytes for Plaster and Concrete. A draft report on Barytes aggregates for concrete and plaster for use as protection against radiation hazards has been issued and circulated for comment The Committee met subsequently to consider the comments for incorporation into the final document.

Technical Committee on Radiographic examination of welded joints. A Sub-Committee's draft on General recommendations for the Radiographic Examination of fusion-welded pipes has been submitted to industry for comment and is being revised in the light of these comments for final approval by the main Committee.

Sub-Committee on Terminology of Casting Defects. The standard prepared by the Committee was published in August as B.S.2737:1956.

O. W. HUMPHREYS,
President.

J. TAYLOR,
Honorary Treasurer.

F. A. VICK,
Honorary Secretary.

H. R. LANG,
Secretary.

THE INSTITUTE OF PHYSICS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1956

1955 £		£
	To Office and general expenses :—	
3,341	Salaries and National Insurance	3,792
180	Staff superannuation	173
1,141	Rent, rates, heating, cleaning, maintenance, etc.	1,331
681	Board, Committees and Officers' travelling expenses	778
521	Printing and stationery	588
354	Bulletin	1,527
373	Postage and telephones	544
294	Miscellaneous expenses	311
6,885		9,044
420	„ Depreciation of furniture, fittings and office machinery	1,205
2,052	„ Copies of Journals supplied to Members	—
359	„ Amount written off expenditure on alterations, improvements and adaptation to House	378
985	„ Leasehold Redemption Policy	985
5,000	„ Grant to Endowment Trust Fund	3,500
—	„ Balance being excess of income over expenditure carried to Reserve Fund	935
£15,701		£16,047

1955 £			£
12,383	By Members' subscriptions		13,171
738	„ Entrance and other fees		862
80	„ Dividends and interest less tax		88
	„ Contribution from Endowment Trust Fund for alteration of premises, depreciation of furniture, fittings, office machinery and leasehold redemption policy :—		
	Charged to cost of publications	1,284	
1,323	Charged to other work	642	1,926
1,177	„ Balance being excess of expenditure over income carried to Reserve Fund		—
£15,701			£16,047

THE INSTITUTE OF PHYSICS

BALANCE SHEET, 31st DECEMBER, 1956

1955 £		£	£
	Life Membership Fund :		
	As at 31st December, 1955...	4,906	
	Less : Transfer to Reserve Fund in respect		
4,906	of deceased members	74	4,832
	Reserve Fund :		
	As at 31st December, 1955...	17,433	
	Add : Transfer from Life Membership Fund	74	
	Sinking Fund Leasehold Property...	985	
	Income and Expenditure Account—		
17,433	Balance	935	19,427
1,770	**Mrs. Phillips' Bequest**		1,770
	Current Liabilities :		
	Payments received from members in advance	724	
3,459	For Expenses	2,663	3,387
£27,568			£29,416

O. W. HUMPHREYS, *President.*
J. TAYLOR, *Honorary Treasurer.*

1955 £		Cost to 31/12/55 £	Additions during year £	Depreciation to 31/12/55 £	Depreciation during year £	£
	FIXED ASSETS :					
2,084	Furniture, fittings and office equipment ...	5,593	430	3,508	1,205	1,310
6,515	Alterations, improvements and adaptation of premises ...	10,289	—	3,774	378	6,137
8,599						7,447
	CURRENT ASSETS :—					
422	Stock on hand—stationery				562	
1,339	Debtors—sundry accounts				1,226	
4,716	Due from Endowment Trust Fund ...				7,441	
78	Subscriptions in arrears				29	
	Investments :					
4,485	Quoted				4,980	
1,000	Unquoted				500	
	(*Estimated market value on 31st December, 1956, £4,787*)					
5,910	Leasehold Redemption Policy				6,895	
1,019	Bank balances and cash in hand ...				336	21,969
£27,568						£29,416

Report of the Auditors to The Members of The Institute of Physics

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account have been kept by the Institute so far as appears from our examination of those books, and proper returns adequate for the purposes of our audit have been received from Branches of the Institute not visited by us. We have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of the Institute. In our opinion and to the best of our information and according to the explanations given to us the said accounts give the information required by the Companies Act, 1948, in the manner so required and the Balance Sheet gives a true and fair view of the state of the Institute's affairs as at 31st December, 1956, and the Income and Expenditure Account gives a true and fair view of the excess of expenditure over income for the year ended on that date.

Spencer House, South Place, London, E.C.2.
7th February, 1957

KNOX, CROPPER & CO., *Chartered Accountants.*

THE INSTITUTE OF PHYSICS—ENDOWMENT TRUST FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1956

1955 £		£
700	To Graduates and National Certificates Examination	749
2,093	„ Expenses of Branches and Groups	2,499
134	„ Conference expenses	1,293
195	„ Educational booklets and reports	273
35,682	„ Cost of production and distribution of publications sold...	36,065
5,851	„ Proportion of overhead charges in connection with the work carried on by the Trust ...	6,777
441	„ Contribution to cost of repairs and alterations of House, depreciation of furniture and Leasehold Redemption Fund	642
1,636	„ Balance, carried down	395
£46,732		£48,693
1,786	To Balance being deficit brought forward	150
—	„ Balance, carried forward	245
£1,786		£395

1955 £		£
665	By Fees for examinations	788
210	„ Donations	157
339	„ Interest	552
40,518	„ Receipts from publications, including advertisements	41,708
5,000	„ Grant from The Institute of Physics	3,500
—	„ Receipts for conferences	1,212
—	„ Non-members' conference fees	776
£46,732		£48,693
1,636	By Balance, brought down	395
150	„ Balance being deficit carried forward	—
£1,786		£395

BALANCE SHEET, 31st DECEMBER, 1956

1955 £		£	£
	ENDOWMENT TRUST FUND :		
100	As at 31st December, 1955	100	
150(Def.)	*Add :* Income and Expenditure Account —Balance	245	345
2,000	Reserve for book stock depreciation		2,000
	CURRENT LIABILITIES :		
12,184	X-Ray Index Fund		16,960
5,510	Publications, subscriptions in advance		8,965
3,765	Printing and publishing expenses		2,972
4,716	Due to The Institute of Physics		7,441
£28,125			£38,683

O. W. HUMPHREYS, *President.*
J. TAYLOR, *Honorary Treasurer.*

1955 £		£	£
	INVESTMENTS :		
5,309	Quoted	6,799	
1,500	Unquoted	—	6,799
	(*Estimated market value at 31st December, 1955, £6,000*)		
2,254	SAVINGS BANK DEPOSITS		3,333
5,753	STOCK ON HAND—PUBLICATIONS AND DISPATCH MATERIAL		4,338
3,544	SUNDRY DEBTORS, PUBLICATIONS, ETC.		5,614
9,765	BANK BALANCES AND CASH IN HAND		18,599
£28,125			£38,683

We have audited the above Balance Sheet and have obtained all the information and explanations we have required. We have verified the Bank Balances and the Investments. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Fund according to the best of our information and the explanations given to us and as shown by the books of the Fund.

Spencer House, South Place, London, E.C.2. KNOX, CROPPER & Co., *Chartered Accountants.*
7th February, 1957

THE INSTITUTE OF PHYSICS—BENEVOLENT FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1956

1955 *£*		£	*1955* *£*		£
436	To Grants	614	*909*	By Subscriptions and donations	1,252
751	,, Balance being excess of income over expenditure carried to Capital Account	891	*135*	,, Interest	148
			143	,, Royalties on books	105
£1,187		£1,505	*£1,187*		£1,505

BALANCE SHEET 31st DECEMBER, 1956

1955 *£*		£	£	*1955* *£*		£
	Capital Account :			*2,633*	Government securities at cost ... ... (*Estimated market value at 31st December, 1956, £2,170*)	2,633
	On 31st December, 1955	5,224		*27*	Debtors	27
5,224	*Add :* Transfer from Income and Expenditure Account	891	6,115	*2,186*	Cash on deposit at Post Office Savings Bank ...	2,752
				378	Cash at bank	703
£5,224			£6,115	*£5,224*		£6,115

J. TAYLOR, *Chairman of Fund Committee.*
H. R. LANG, *Secretary of the Committee.*

We have audited the above Balance Sheet and have obtained all the information and explanations we have required. We have verified the Bank Balances and the Investments. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Fund according to the best of our information and the explanations given to us and as shown by the books of the Fund.

Spencer House, South Place, London, E.C.2.
7th February, 1957

KNOX, CROPPER & CO., *Chartered Accountants.*

PHYSICIST or ELECTRICAL ENGINEER required by Ministry of Supply Proof and Experimental Establishment, Shoeburyness, Essex, to lead section engaged on development of methods of ballistic measurement. Candidates should have 1st or 2nd class honours degree or equivalent in physics or electrical engineering, with at least three years' postgraduate research experience. Knowledge of optics and electronics (including radar) an advantage. Appointment according to age, experience, etc. as Senior Scientific Officer. Salary within range £1,075–£1,265 (superannuable). Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A67/7A. Closing date April 24, 1957.

PHYSICIST or ELECTRICAL ENGINEER required by Ministry of Supply at R.A.E., Farnborough, Hants, for work on aerials generally, and possibly on related field of radio wave propagation. Candidates should have 1st or 2nd class honours degree in physics or electrical engineering, and be capable of applying radiation theory. Appointment as Scientific Officer (min. age 21). Salary within range £565–£995 p.a. (superannuable). Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A82/7A. Closing date April 24, 1957.

PHYSICISTS or ELECTRICAL ENGINEERS required by Ministry of Supply, R.A.E., Farnborough, Hants, for analysis work on problems connected with communication systems. Candidates should have 1st or 2nd class honours degree in physics or electrical engineering or equivalent. Applications from mathematical physicists or applied mathematicians also considered. Appointments as Scientific Officer (min. age 21). Salary within range £565–£995 (superannuable). Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A77/7A. Closing date April 24, 1957.

NON-DESTRUCTIVE TESTING TECHNIQUES

Attractive and responsible positions are offered in the development of new techniques for the non-destructive examination of materials.

Senior and junior staff are required with qualifications or experience in the fields of physics or physical metallurgy with particular reference to the non-destructive examination of materials or industrial instrumentation and measurement. Salaries commensurate with qualifications and experience will be paid.

Application should be made in writing in the first instance giving full details of qualifications, previous experience, age and salary required, and be addressed to: Personnel Department, Kelvin & Hughes Ltd., New North Road, Barkingside, Essex.

UNIVERSITY OF OTAGO

DUNEDIN, NEW ZEALAND

Applications are invited for the position of Lecturer in Physics.

Salary range £985–£1,235 per annum.

Further particulars are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in New Zealand and London on May 15, 1957.

SCIENTIFIC OFFICERS (mathematicians and physicists) required by Ministry of Power, Safety in Mines Research Establishment, Sheffield and Buxton. Qualifications 1st or 2nd class honours degree or equivalent. Duties: Choice of research topics including: (i) electron microscopy and X-ray diffraction. (ii) Stress analysis by photo-elasticity and strain gauges; non-destructive testing by ultrasonics and radioactive isotopes. (iii) Relation between parameters of interrupted electric circuits and probability of igniting inflammable gas, involving some electronic computation. (iv) Gas detection and measurement by optical, acoustic, chemical and electrical methods. (v) Mathematical studies of: aerodynamic effects in mine roadways; elastic and plastic behaviour of strata over coal seams; transients in electrical circuits, etc. (vi) Invention and design of electrical, electronic and mechanical instruments. (vii) Detection, prevention and extinction of mine fires and use of water-air foams for their extinction. (For this work some knowledge of chemistry an advantage.) Salary: £585–£1,025 Sheffield, £565–£995 Buxton. Starting salary according to age and experience. Prospects of establishment later. Preference given to candidates under age 31. Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A79/7A.

UNIVERSITY OF MALAYA

Applications are invited for (1) Lectureship or (2) Assistant Lectureship in Physics. Salary scales (1) £1,148 × £49–£1,442–£1,540 × £56–£1,820 p.a. (2) £1,001 × £49–£1,099 p.a., entry point determined by qualifications and experience. Allowances: expatriation £280–£308 p.a., cost of living £210–£560 p.a., all paid in Malayan currency. Passages for appointee, wife and children under 12 years. Part-furnished quarters at reasonable rent. Provident Fund Scheme. Duties to be assumed as soon as possible.

Detailed applications (six copies) naming three referees by April 30, 1957, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

£650–£1,000 per annum offered to **GRADUATE PHYSICISTS** to be employed in applications and research sections of rapidly expanding public company. These sections are concerned with the research, development and application of radio-isotopes and nucleonic instruments to industrial problems, reactor and laboratory instrumentation. Some industrial experience would be of advantage but is not necessary. Successful applicants will ultimately be included in staff pension scheme. Apply: Secretary, Isotope Developments Ltd., Beenham Grange, Aldermaston Wharf, Nr. Reading, Berks. Tel. Woolhampton 451.

PHYSICIST or ELECTRICAL ENGINEER required by Ministry of Supply at R.A.E., Aberporth, Cardiganshire, to work in section doing research and development on electronic instrumentation. Candidates should have 1st or 2nd class honours degree or equivalent in physics or electrical engineering. Some electronics experience required. Appointment as Scientific Officer (Min. age 21) with salary in range £565–£995 (superannuable). Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A92/7A. Closing date May 24, 1957.

BRITISH

CELLOPHANE LIMITED

Bridgwater

has vacancies for

PHYSICISTS

in its

Research and Development

Laboratories

as follows :

Physicist, age 25/50, to lead a team of chemists, physicists and engineers engaged upon the laboratory and plant development of plastic films other than cellulose and polythene. Candidates should have an honours degree—a higher degree would be an advantage. Practical experience of research and development work on a laboratory and pilot plant scale, and the co-ordination of the work of graduate staff, essential. Ref. No. R50. IP.

Physicists, age 25/50, of honours degree standard. The work involved will be laboratory, pilot plant, and plant scale development in connexion with cellulose and plastic films. Previous related experience is desirable but not essential.
Ref. No. R51. IP.

Application forms may be obtained from the Personnel Officer, British Cellophane Limited, Bridgwater, Somerset.

PHYSICIST

The GENERAL CHEMICALS DIVISION of I.C.I. LTD., has a vacancy in its Research Department at Widnes, Lancashire, for a PHYSICIST to work in the first place on the generation, propagation and application of ultrasonic radiation. Candidates should have a good Honours Degree in Physics and the position offers excellent prospects for the right man. The conditions of employment include membership of the Pension Fund, a Profit-Sharing Scheme. and good sports and recreational facilities. Help can be given to married men in connection with house purchase and removal expenses. Applications should be made in writing, giving particulars of age, qualifications and experience (quoting PH24) to the

Staff Manager,
Imperial Chemical Industries Limited,
General Chemicals Division,
Cunard Building,
Liverpool, 3.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
PHYSICS DEPARTMENT, INSTRUMENT TECHNOLOGY SECTION

Applications are invited for the following posts :—

1. Lectureships : Salaries according to qualifications, ranging from £700 × £50–£1,000 and £1,000 × £50–£1,400 per annum ;
2. Research Fellowships : Salary range £600 × £50–£1,000 per annum.

The latter may later be appointed to permanent staff. Duties of (1) teaching normal physics course and research ; (2) research only. Research facilities mainly in photo-electronics applied to scientific research.

Apply with full personal and academic record and names of two referees to Professor Instrument Technology, Physics Department, Imperial College, London, S.W.7.

OSRAM LAMP DEVELOPMENT LABORATORY

Physicists with or without industrial experience are invited to apply for posts in a new and expanding section of this laboratory. The work of the section covers broadly the investigation and development of new incandescent light sources and their production processes and testing techniques.

Graduates without experience may be offered starting salaries in the range £600–£750 per annum, and appointments at higher starting salaries are available to applicants with relevant industrial experience.

Staff are required who will display considerable initiative and versatility on work of an interesting and varied nature, and training will be given with the potentiality of rapid promotion to posts as Senior Development Engineers. The posts are permanent and pensionable after a qualifying period.

Interested applicants are invited to apply to : The Personnel Officer, G.E.C. Ltd., Osram Lamp Works, Brook Green, Hammersmith.

PHYSICIST required by Ministry of Supply in Metallurgy Department, R.A.E., Farnborough, Hants, for fundamental work on defects in metals and their mechanical properties. Successful applicant also expected to interest himself in specialized mechanical testing work. Candidates should have 1st or 2nd class honours degree or equivalent in physics, but those graduating this year may apply. Appointment as Scientific Officer (min. age 21). Salary within range £565–£995 p.a. (superannuable). Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A81/7A. Closing date April 24, 1957.

PHYSICISTS or ELECTRICAL ENGINEERS required by Ministry of Supply at R.A.E., Farnborough, Hants, to develop and design circuits to deal with special problems. Candidates should have 1st or 2nd class honours degree in physics or electrical engineering. Physicists should have engineering bias, and Engineers leaning towards Physics. Appointments as Scientific Officer (min. age 21) with salary in range £565—£995 (superannuable). Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A83/7A. Closing date April 24, 1957.

PHYSICIST, graduate required for Research Laboratories of British Insulated Callender's Cables at Shepherd's Bush. The work involves the investigation of the electrical and physical properties of dielectrics and the study of deterioration, and offers wide scope for initiative. Previous experience is not essential but would be desirable. Five-day week. Pension Fund. Applications giving details of age, experience should be made to Manager (Personnel), B.I.C.C. Ltd., Norfolk House, Norfolk Street, London, W.C.2. Reference W.L.1.

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR

Applications are invited for the post of Lecturer in Theoretical Physics. The salary scale is £900 × £50–£1,350 × £75–£1,650 and the initial salary will be dependent on the qualifications and experience of the person appointed. In addition there will be F.S.S.U. benefits and family allowances. The appointment will date from October 1, 1957. Two copies of the application should reach the undersigned, from whom further particulars may be obtained not later than May 6, 1957.

Kenneth Lawrence,
Secretary and Registrar.

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR

Applications are invited for the post of Lecturer in the Department of Electronic Engineering. Preference will be given to candidates with research experience in valve or circuit electronics.

The salary scale is £900 × £50–£1,350 × £75–£1,650 and the initial salary will be dependent on the qualifications and experience of the person appointed. In addition there will be F.S.S.U. benefits and family allowances. The appointment will date from October 1, 1957. Two copies of the application should reach the undersigned, from whom further particulars may be obtained, not later than May 6, 1957.

Kenneth Lawrence,
Secretary and Registrar.

ASSISTANT EXPERIMENTAL OFFICER required by the Atomic Weapons Research Establishment, Aldermaston, Berkshire, for duty at Orfordness, Suffolk, to be a member of a team engaged on complex field trials. The work includes telemetry, communications and radar type techniques and involves use of electronic instruments and subsequent analysis of results. Minimum qualification, G.C.E., in five subjects including Mathematics or science (Advanced Level) or equivalent, but H.N.C. or a degree in physics or electrical engineering with electronics an advantage. Previous experience in one of following fields desirable: U.H.F. and V.H.F. communications, telemetry devices, pulse techniques, Analysis of experimental data or technical writing. Salary: £375 (age 18)–£665 (age 26 or over)–£815 p.a. (male). Contributory superannuation scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance. Postcards for application forms to the Senior Recruitment Officer, at A.W.R.E., Aldermaston. Please quote ref. 1460/110.

Applications are invited by the Department of Physics from honours graduates in physics, chemistry or in a biological subject, for Studentships leading to the degree of M.Sc. or Ph.D. in biophysics (University of London). The studentships normally extend over two years and carry an allowance of £400 per annum. Detailed applications, naming two referees, for places available from October 7, 1957, should be received by the Director, Department of Physics, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3, not later than April 22, 1957.

Applications are invited for appointment as Assistant Lecturer or Lecturer in physics. Applications (three copies) stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained), not later than May 1, 1957.

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE

Applications are invited from engineers and physicists with experience in industry or of industrial research, for a post as Lecturer in civil or mechanical engineering from October 1, 1957. The salary scale for lecturers is £900–£1,650 with superannuation and family allowances. Starting salary according to qualifications and experience. Six copies of application, together with the names of three referees, should be sent not later than May 4, 1957, to the undersigned, from whom further particulars may be obtained.

E. R. Evans,
Registrar.

University College, Cathays Park, Cardiff.

GEOPHYSICISTS, experienced, and University Graduates with degree in geophysics, geology, mining, mathematics, physics or electrical engineering, interested in oil exploration by means of the seismograph, now have an excellent opportunity to live and work in foreign countries. Good salary, excellent bonus and living allowance paid for foreign service. Write details of age, education and experience to G.S.I. Ltd., Eagle Chambers, Rosehill Court, Morden, Surrey.

THE BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION

(Shirley Institute)

Physicist or Engineer. A vacancy exists for a young physicist or engineer, to work on physical problems associated with the development of automation in the textile industry. The work is interesting and varied and concerned initially with the design and application of automatic control systems and with mechanical handling. Candidates should be capable of a fundamental approach to these problems but should have an interest in applying the results in practice. The post offers a progressive scientific career at the Institute, and the initial salary will be in the range £600–£900. The post carries with it participation in the Federated Superannuation System for Universities. Applications, giving full particulars of qualifications and careers, should be sent to: Dr. D. W. Hill, Director of Research Shirley Institute, Manchester, 20.

CITY OF PORTSMOUTH

College of Technology

ASSISTANT LECTURER (GRADE B)

Assistant Lecturer (Grade B) required in September to teach physics and mathematics.

Applicants should have a good degree or equivalent qualification. Industrial experience would be an advantage.

Salary: Burnham Technical Scale £650–£1,025 (men), £580–£820 plus equal pay increments (women) —with graduate and training allowances and increments for professional or industrial experience where applicable. Further particulars and form of application should be obtained from the Registrar as soon as possible.

E. G. Barnard,
Chief Education Officer.

MOUNT VERNON HOSPITAL

Northwood, Middlesex

Applications are invited for the post of Hospital Physicist (N.H.S. basic grade). Salary in accordance with the Whitley Council Scale: Probationary period £525 × £25 - £625 p.a. for 1st or 2nd class honours degree (£475 × £25 - £575 p.a. for other entrants); after probationary period (normally two years) £650 p.a. × £30 (3) × £35 (3) - £845 p.a. The work will mainly be concerned with dosimetry and treatment planning in connection with radiotherapy.

Applications stating age, qualifications and post-graduate experience (if any), together with the names of two referees, should be sent as soon as possible to the Secretary and House Governor.

ESSEX EDUCATION COMMITTEE

South-East Essex Technical College and School of Art,
Longridge Road, Dagenham

Applications are invited for appointment as Research Assistants to carry out fundamental research in :—

(*a*) Problems in organic chemistry (2 posts).

(*b*) Electronics, high vacuum problems or interferometry (1 post).

Candidates should hold a good honours degree.

Salary £300 per annum plus additional payment for part-time teaching. Further details (stamped addressed foolscap envelope) from the Clerk to the Governors at the College.

X-RAY RESEARCH. There is a vacancy in the X-ray department of Hilger and Watts Ltd. for a young graduate physicist or chemist, with some knowledge of X-ray crystallography. The successful applicant will be selected from those who have a keen desire to develop their knowledge of X-ray diffraction techniques, and facilities will be provided for carrying out work in this field with a view to keeping abreast of modern developments with particular reference to their application to instrument design. Five-day week, canteen and superannuation scheme. Please write quoting ref. A70 to the Personnel Officer, Hilger and Watts Ltd., 98 St. Pancras Way, Camden Road, N.W.1.

Chartered Patent Agents

W. H. BECK, GREENER & CO.

7 Stone Buildings,
Lincoln's Inn,
London, W.C.2

Chancery 2535

Courses

CITY OF OXFORD EDUCATION COMMITTEE

College of Technology Art and Commerce

(Principal: Howard Buckley, A.R.C.A., A.T.D.)

A full-time course for one academic year leading to the examination for Graduateship of The Institute of Physics is to begin in September, 1957. Intending students should hold a good Higher National Certificate in Applied Physics.

Full details obtainable from the Head of the School of Science, College of Technology, Art and Commerce, Cowley Road, Oxford.

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

PHYSICIST required by Ministry of Supply at R.A.E., Bedford, to lead a team engaged on research and development of radio, radar and electronic guidance systems used in manual and automatic approach and landing of aircraft in all weather conditions. 1st or 2nd class honours degree or equivalent in physics. At least three years' postgraduate research experience essential. Appointment according to age, research experience, etc., as Principal Scientific Officer (min. age 31) or Senior Scientific Officer (min. age 26). Salary: P.S.O. £1,295 – £1,850; S.S.O. £1,075 – £1,265 (superannuable).
Forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A116/7A. Closing date May 24, 1957.

BRITISH CELANESE LTD., invites applications from Graduate Physicists up to 30 years of age for research appointments at their factory at Spondon, near Derby. The work will be particularly concerned with the application of the methods of physics to the solution of textile problems and will afford a valuable introduction to a career in the textile industry. Salary in accordance with age and qualification; pension scheme. Please reply to the Personnel Manager, British Celanese Ltd., Celanese House, Hanover Square, London, W.1, quoting Ref. 1231.

ROTHERHAM COLLEGE OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL ENGINEERING AND PHYSICS
COURSE IN HIGH VACUUM TECHNOLOGY

A short full-time course on the production and measurement of high vacuum will be held from July 1 to July 5 inclusive.
The course will deal with the construction of all the usual forms of vacuum pump and gauge, care and maintenance of pumps and gauges and vacuum plumbing.
The course will be of an introductory nature for those who have need of high vacuum as an ancillary to their normal duties but have little or no actual knowledge of vacuum techniques. A reasonable proportion of the time will be allocated to practical work and visits to local industry using vacuum methods.
Further particulars from the Registrar, College of Technology, Howard Street, Rotherham.

RESEARCH ON DIELECTRICS.—Physicist, graduate, required in the research laboratories of British Insulated Callender's Cables Ltd. at Shepherds Bush. The work involves research on the dielectric properties of polymers and the development of improved methods for dielectric measurements. Knowledge of the dielectric properties of solids and of measurement techniques is desirable and keen interest in these fields is essential. Five-day week. Pension Fund. Applications in the first instance, giving details of age, qualifications, experience and salary required, should be made to Manager (Personnel), BICC Ltd., Norfolk House, Norfolk Street, London, W.C.2, quoting reference W.L.4.

SCIENCE GRADUATE interested in working abroad, required by large American Geophysical Company expanding in the Eastern Hemisphere. Applicants with experience in geophysical techniques preferred but inexperienced graduates with degree in geology, mathematics, physics or electrical engineering will be considered. Generous foreign bonus and living allowance. Excellent prospects for men with ability and initiative who are prepared to work hard. Write details of age, marital status, education and experience to G.S.I. Ltd., Eagle Chambers, Rosehill Court, Morden, Surrey.

RESEARCH PHYSICISTS are invited to apply for appointments to the Central Research Department of The Morgan Crucible Co. Ltd., at Battersea. Candidates aged under 35 should hold an honours degree in physics, or an equivalent qualification, and have had some industrial experience, preferably involving strength of materials and/or electricity. The range of work is very wide and includes the development and application of physical tests. Appointments will be made to the permanent staff and will carry generous superannuation benefits and non-contributory life cover; there are full welfare amenities including a staff canteen. Please write, in strict confidence, to the Staff Department, Battersea Church Road, S.W.11, and quote reference UZ/12.

Solid State Computer Techniques

The Nelson Research Laboratories

of the English Electric Co. Ltd., have vacancies for

GRADUATE PHYSICISTS
and
ELECTRONIC ENGINEERS

for research into the design and development of new components and units for use in digital computers. Previous experience of semiconductor, magnetic or vacuum work would be an advantage. Salary according to age and experience.

Applications should be addressed to
Central Personnel Services
Marconi House, 336/7 Strand, W.C.2,
quoting Ref. BP913E.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER 17

ENGINEERS AND PHYSICISTS

There are opportunities for Engineers and Physicists in the Research Department and Scientific Apparatus Department of the Company.

An important field of interest is that in which electrons or ions are produced and utilized in vacuum. Specific applications are found in particle accelerators, high power radio valves, electron microscopes, mass spectrometers, etc. Work, of a fundamental and developmental nature, is in progress, and there are openings for men with either academic or practical interests.

Conditions of employment compare favourably with other industrial organizations.

Opportunity is given for original work and the publication of papers is encouraged.

Application should, in the first instance, be made to

THE MANAGER, RESEARCH DEPARTMENT,
METROPOLITAN-VICKERS ELECTRICAL CO. LTD., TRAFFORD PARK, MANCHESTER, 17.
Quoting reference " C.P.8 "

PLESSEY NUCLEONICS LTD., have a vacancy for a Physicist whose interest lies in devising and carrying out basic experiments. The successful applicant will become a member of a team engaged upon designing new methods and instruments for nuclear reactor measurement and control. Considerable scope will be given to develop new and original ideas. The salary for this post will be on a generous scale depending upon previous experience and qualifications. Applicants should write in confidence giving full particulars to the Chief Engineer, Plessey Nucleonics Ltd., Weedon Road, Northampton.

AUSTRALIA
UNIVERSITY OF QUEENSLAND

Applications are invited for the position of Senior Lecturer in Theoretical Physics. The appointee must hold a doctorate of philosophy or science, awarded for research in theoretical physics. Previous lecturing experience is desirable.
Salary £A1,850 – £A2,150 per annum.
Further particulars are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London on June 7, 1957.

MEDICAL RESEARCH COUNCIL. Vacancy for a Junior Physicist to assist with clinical applications and research using the X-ray and electron beams from the 8 MeV linear accelerator. Some experience of hospital physics or electronics desirable but 1957 graduates will be considered. Apply Director, Radiotherapeutic Research Unit, Hammersmith Hospital, London, W.12.

VACUUM PHYSICS

RESEARCH GROUP

A valve Engineer is required for work on special klystrons and microwave oscillators. Applicants should possess a degree (physics or engineering) or equivalent qualification, together with some experience. The appointments are to a fast developing team engaged on advanced research. Applications are also invited from persons with Inter B.Sc. or O.N.C. for appointment as a Technical Assistant in this field. Please write to the Personnel Manager (ref. 280), Elliott Brothers (London) Ltd., Borehamwood, Herts.

Applications are invited for an appointment as Physicist or Engineer with the European Organization for Nuclear Research, Geneva, Switzerland. Will be required to work on design and development of bunching and focusing devices for proton linear accelerator. Must have had postgraduate experience in field of particle accelerators or vacuum and high frequency experience. Salary : £1,010 – £1,905 (approximately) p.a. (according to qualifications and experience), tax free, paid in Swiss francs. Installation, family, and non-residence allowance, and education grant also payable. Travelling and removal expenses paid. Provident fund and health insurance scheme. Duration : three years in the first instance.
For further information and application forms write Ministry of Labour and National Service (E9), Almack House, King Street, S.W.1, quoting A12/SW1/CERN/9.